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First Copy
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IRON and STEEL ENGINEER

FUEL — ELECTRICITY — MACHINERY — METHODS

EMPIRE BUILDING, PITTSBURGH, PA.

To Educate the Engineer in Industry

NOVEMBER 1924

Containing the Proceedings of the A.I.&S.E.E.

Interchange of Power in the Southeastern States

By J. M. OLIVER, Electrical Engineer, Alabama Power Company, Birmingham, Ala.

Electric Mining Equipment, Its Selection, Care and Operation

BY A. F. ELLIOTT, Electrical Superintendent, Sloss Sheffield Steel & Iron Company, Birmingham, Ala.

Discussion: Developments in Electric Maintenance Shop Practice

By W. H. BURR, Electrical Superintendent, Lukens Steel Company, Coatesville, Pa.; N. E. DREXLER, Chief Engineer, Newport News & Hampton Railway, Gas & Electric Company, Hampton, Va.; JESSE L. JONES, Metallurgist, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.; A. L. REICHERT, Electrical Engineer, The Bourne Fuller Company, Cleveland, Ohio; G. A. ROWE, Foreman Armature Department, Carnegie Steel Company, Duquesne, Pa.; D. W. BLAKESLEE, Electrical Engineer, Jones & Laughlin Steel Corporation, Pittsburgh, Pa.; A. W. BOLEY, Electrical Repair Shop Foreman, Jones & Laughlin Steel Corporation, South Side Works, Pittsburgh, Pa.; A. W. MOHRMAN, Electrical Department, Otis Steel Company, Cleveland, Ohio; A. HOYT LEVY, Engineer, United American Metals Corporation, Brooklyn, N. Y.; JOHN GLEW, Chief Electrician, Ashtabula Sheet Steel Company, Ashtabula, Ohio; B. A. CORNWELL, Electrical Engineer, Carnegie Steel Company, Youngstown, Ohio; ARTHUR J. WHITCOMB, Formerly with Mark Manufacturing Company, Indiana Harbor, Ind.; G. E. STOLTZ, General Engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.; W. G. COLSON, Works Engineer, American Steel Foundries, Granite City, Ill.; A. J. STANDING, Superintendent Electrical Department, Saucon Plant, Bethlehem Steel Company, Bethlehem, Pa.; W. T. SNYDER, Electrical Superintendent, National Tube Company, McKeesport, Pa.; GEORGE RICHARDSON, Electrical Superintendent, American Bridge Company, Pencoyd, Pa.; O. W. BODLER, Electrical Engineer, Eastman Kodak Company, Rochester, N. Y.; J. A. MORGAN, Superintendent Electrical Department, Edgar Thomson Works, Carnegie Steel Company, Braddock, Pa.; JOHN C. REED, Electrical Superintendent, Bethlehem Steel Company, Steelton, Pa.; F. O. SCHNURE, Electrical Superintendent, Bethlehem Steel Company, Sparrows Point, Md.

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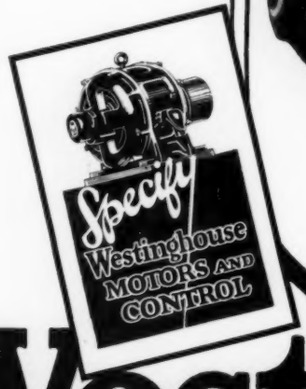

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IRON AND STEEL ENGINEER

J. F. KELLY, Editor

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Copyright, 1924, by Association of Iron & Steel Electrical Engineers.

Published Monthly by

Association of Iron and Steel Electrical Engineers

706 Empire Building, Pittsburgh, Pa.

Entered as second-class mail matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879.

Subscription Price $5.00 per Year. Single Copy 50c.

MEETINGS and PAPERS

PHILADELPHIA SECTION

P. T. Vanderwaart, Chairman **L. O. Morrow, Secretary**

Saturday, December 6th, 1924

"Essentials of Design of Electric Industrial Furnaces and Their Application to Building Up Load Curves," by George P. Mills, Engineer, General Furnace Company, Philadelphia, Pa.

Engineers Club **Philadelphia, Pa.**

CHICAGO SECTION

R. L. McIntosh, Chairman **W. H. Williams, Secretary**

Thursday, December 4th, 1924

"Automatic Substations"

Atlantic Hotel **Chicago, Ill.**

CLEVELAND SECTION

A. W. Mohrman, Chairman **A. R. Lintern, Secretary**

Saturday, December 13th, 1924

"Special Features in D. C. Control," by Mr. W. Dean, Chief Engineer, Sundh Electric Company, Newark, N. J.

Electric League Rooms, Statler Hotel **Cleveland, Ohio.**

PITTSBURGH SECTION

R. E. Lewis, Chairman **John F. Kelly, Secretary**

Saturday, December 13th, 1924

"Welding"
Thermit, Electric Arc, Oxy-acetelyne

William Penn Hotel **Pittsburgh, Pa.**

BIRMINGHAM SECTION

F. G. Cutler, Chairman **W. W. Garrett, Secretary**

W. H. Dunn **Executive Committee** **W. H. Gilbert**
A. F. Elliott **W. B. Connally**

Saturday, November 22nd, 1924

"Automatic Stations and Their Remote Supervisions", by Chester L. Lichtenberg, General Electric Company, Schenectady, N. Y.

EDITORIALS

WELDING

TODAY thousands of tons of steel castings, forgings and machinery filters through the scrap departments, and the question often arises, how may we prevent this enormous waste? The answer is A MODERN WELDING DEPARTMENT, organized and equipped similar to any other modern maintenance departments.

It seems that the uses of the modern welding methods today are not fully appreciated by our industry as they should be, when it is taken into consideration that it is possible to recover a large portion of the castings, forgings, and machinery which now is broken up and melted down.

There are three branches of welding, and all of them have their particular application namely: the use of thermit, oxy-acetelyne and arc welding.

Some steel plants have had the foresight to organize a welding department, and the amount of material that they are able to recover each year is enormous. It certainly would surprise many engineers to learn the advances that have been made in this art, and for those steel companies who are today sending carloads and carloads of steel castings and forgings to the scrap department we would advise them to investigate the merits of the present day welding art.

MAINTENANCE

ELECTRICAL engineers and superintendents in the steel industry are all confronted with the problem of costs, and as competition becomes keener each year, naturally, the executives, are reaching around, endeavoring to curtail expenditures in usually:

First — The operating departments.
Second—They look at the coal pile.
Third — Then comes the maintenance departments.

It is a difficult matter to determine just where to start to curtail expenditures in a repair shop. One of the first methods is to reduce the force, and this does not always answer the question. The second resource is to patch up machinery, not completely repair it, and finally the purchasing department takes a hand and buys on price.

Reducing the Force.

This method shows on the books as an immediate savings, but the depreciation which follows is often much greater than the apparent savings, yet it is not so easily traced or located, due to the fact that systematized shops are not encouraged as they should be.

Patch, Not Repair Machinery.

This method also shows an immediate reduction in costs on the books, but what follows in a few months? Apparatus is returned to the shops in little better shape than scrap.

Buying On Price.

Here also is shown a savings for a while, and it is also admitted that it is a very difficult matter to show in figures what a harmful practice this is, however, in shops where modern systems, processes, and practices prevail, it is possible to prove that material purchased on price only is in the end the most expensive. A number of engineers and superintendents seem to have answered the question of maintenance to their executive's satisfaction, but how? From what we have been able to learn their success has been based on the following:

First: When purchasing electrical apparatus they have made it a point to specify sizes of motors and controllers which they feel are not only large enough to take care of their present requirements, but that they will also take care of the changes which are being continuously made in steel mills, where the aim is for greater tonnages. At first hand this might seem like poor judgment, a waste of money, however, where this practice prevails in the steel plants which have come to our notice maintenance is not a serious problem, for example: A certain steel plant which has about 25,000 hp. in auxiliary motors requires but one armature winder to preserve the continuity of operation, and in another steel plant which has about 50,000 hp. in auxiliary motors it requires about 15 armature winders. The first steel plant purchases all of their motors a few sizes larger than they require for their present purposes, and the second steel plant purchases motors for their present requirements only, the result being, that the first change that is made to produce greater tonnage the motor is usually too small, and maintenance begins in earnest.

Second: Organization has played a large part in successfully combatting maintenance problems through systematizing and modernizing repair shops. Performance records of apparatus are maintained and it is a simple problem to discover where your repeated breakdowns are occurring.

Third: Shop equipment and processes are all modern. This feature, of course, is only possible through the encouragement of the executives.

In this issue is contained the practices of many of the electrical engineers and superintendents in the steel industry. Each one suggests some clever idea or process tending to reduce maintenance. You are invited to read these articles, and if you have any suggestions to offer, which in your mind, you feel will help to reduce costs, forward them to the association's headquarters, and they will appear in the Iron and Steel Engineer.

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*Interchange of Power in the Southeastern States**

By J. M. OLIVER†

WHILE the proposed Eastern Super-power Zone is still under discussion, a virtual super-power system has been in existance in the South for several years covering the states of Alabama, Georgia, Tennessee, North and South Carolina. The Southern zone consists of the interconnected systems of seven independent companies as follows: Alabama Power Company, Columbus Power Company, Georgia Railway and Power Company, Central Georgia Power Company, Tennessee Power Company, Southern

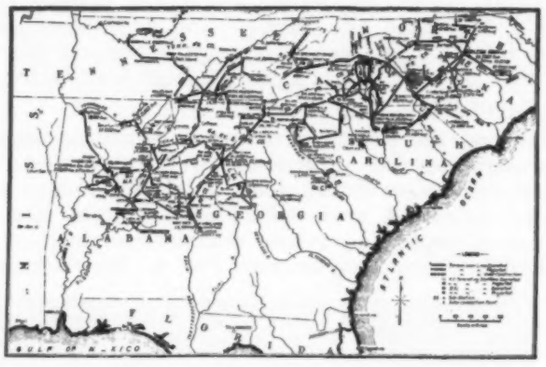

FIG. 1.

Power Company, and Carolina Power and Light Company.

A map of the Southeastern States showing the territory covered by these systems is shown in Fig. 1. It will be noted that the interconnected system forms a complete network over a territory approximately 600 miles long, and 300 miles wide at its greatest width. The aggregate generating capacity, including steam and hydro-electric plants is in excess of 800,000 kw.

The interconnection of these systems was accomplished by the building of tie lines and the installation of sufficient transformer and switching capacity at the tying points, to take care of the exchanged energy. Few changes had to be made in the individual systems themselves as fortunately all the companies involved had already standardized on a frequency of 60 cycles, and most of them operated their principle transmission lines at 110,000 volts.

Although energy has been transferred a distance of about 600 miles on this interconnected system, the use of high voltage trunk lines of the order of 220,000 volts has not been found necessary. It is obvious, of course, that no great bulk of power could be directly transmitted a distance of 600 miles at 110,000 volts, but by a process of relaying the energy from generating stations to adjacent load centers, the same benefits have been accomplished.

For instance, assume that the Carolina Power & Light Company at the extreme Northeastern end of the interconnected system desires to secure a block of power which is to be supplied by the Alabama Power Company. The latter company delivers the required amount of power to the Georgia Railway & Power Company at the Georgia-Alabama state line, which will be absorbed on the Georgia system in that vicinity. The Georgia Railway and Power Company will then transmit energy from its Talullah Falls plant, at the other extreme end of its system, to the Southern Power Company. This company will in turn absorb this energy locally and transmit a like amount from generating stations in the vicinity of the tie point to the Carolina Power and Light Company. The systems relaying the energy, of course, deduct an amount sufficient to cover transmission losses, costs of transmission, etc.

During the Fall of 1921 several of the Southeastern Power Companies recognizing the possibilities accru-

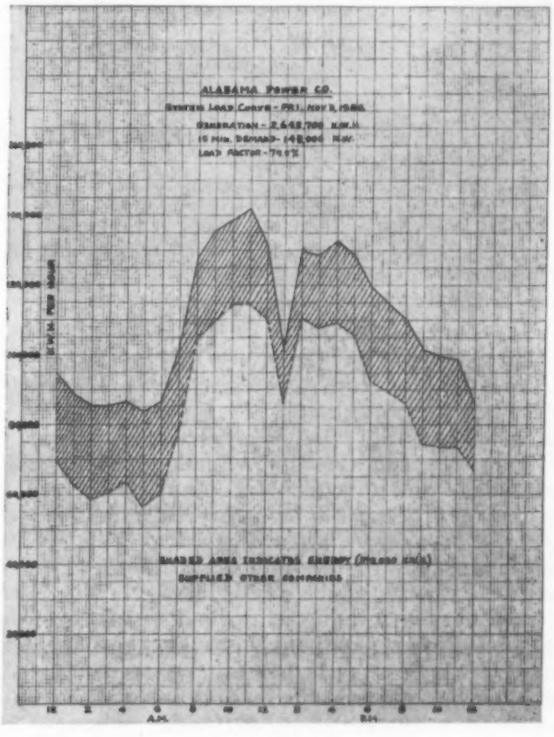

FIG. 2.

ing from the interconnection of the systems and anticipating a power shortage during the dry weather seasons, arranged to secure the use of the then idle steam plant at Muscle Shoals, Alabama. Accordingly the Alabama Power Company leased this plant from the United States Government, and that company in turn contracted with several of the other companies to hold in reserve a certain capacity which could be used by these companies at any time upon reasonable demand.

The Muscle Shoals steam plant is located in the extreme northwest section of Alabama, and connects

*Presented at Birmingham Section.

†Electrical Engineer, Alabama Power Company, Birmingham, Ala.

with the Alabama Power Company's system through a 90-mile, 110,000 volt, single circuit, transmission line at the Warrior River steam plant. Although the Muscle Shoals steam plant has a generating capacity of 60,000 kw., the amount available for distribution by the Alabama Power Company is limited to 30,000 kw. by the transmission line capacity between Muscle Shoals and Warrior Steam Plant.

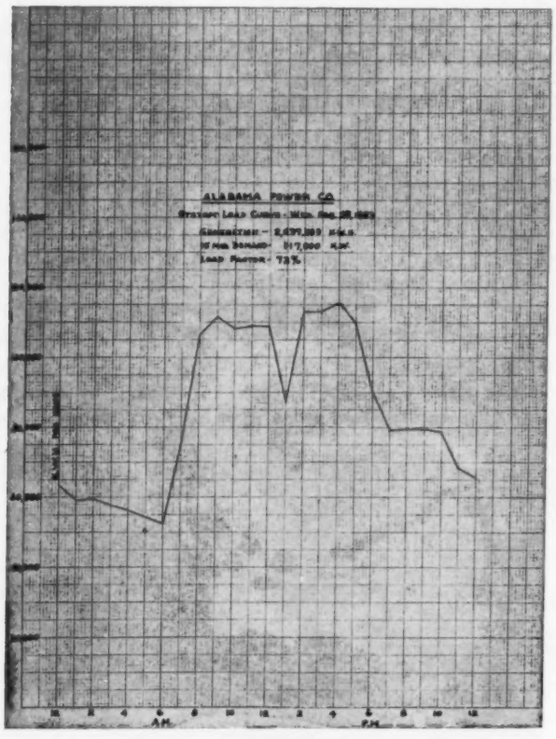

FIG. 3

The value and importance of this arrangement and of the interconnection was clearly demonstrated last year when an abnormally dry season prevailed over the Southeast and relief was given to companies in the Carolinas and Georgia. Some of the companies would have had to curtail power to their customers had they not been able to secure this standby power. A typical load curve when power was being delivered from Alabama to the Georgia Companies and the Carolinas for 24 hours of the day is shown in Fig. 2 where the unshaded area indicates normal system load on the Alabama Power Company's system, and the shaded area the energy delivered to other systems. For comparison a typical system load curve of the Alabama Power Company's system for a day when no interchange of energy took place is shown in Fig. 3.

Since the principle reserve capacity of the interconnected system is at Muscle Shoals the relaying of large blocks of power to date has been principally from Alabama to Georgia and to the Carolinas. There has, however, been considerable power interchanged between some of the neighboring companies. We can, however, only speak of those in which the Alabama Power Company's system took part, namely, between it and the Georgia Railway and Power Company. The benefits derived by interconnection of large power systems have been further demonstrated by the result of the interchange between these two companies. The hydro plants of the Alabama Power Company are flow of river plants with comparatively small storage reservoirs, and the flow of the Coosa River on which these plants are situated, is subject to wide seasonal variations. The bulk of the company's load during the low water seasons of the year is carried by steam generating stations. The principle hydro plants of the Georgia Railway & Power Company, on the other hand, are backed by large storage reservoirs having a capacity to take care of normal seasonal variations in river flow.

During certain seasons of the year it is possible to co-ordinate the operation of the Georgia and the Alabama plants to secure maximum efficiency on each system. For instance, during the season when there is a surplus of water in the flow of river plants, and when water is being stored at the reservoir plants, power is supplied from the Alabama system to the Georgia system during the offpeak hours — the normal load on the Alabama system during offpeak hours being considerably less than the capacity of its hydro plants. This interchange, therefore, permits the operation of the flow of river plants at a very high load factor and conserves water at storage plants.

During the peak load hours it of course becomes necessary for each system to carry its own load and the storage plant draws down a certain amount of its stored water. A typical load curve on the Alabama Power Company's system when supplying offpeak power to Georgia is shown in Fig. 4. By referring to

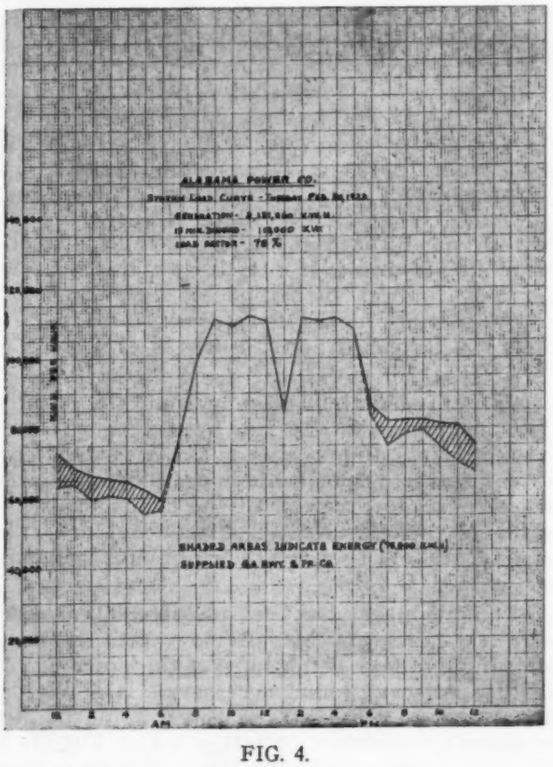

FIG. 4.

Fig. 3 it will be noted that considerable improvement is made in the load factor on the Alabama Power Company's system. Another method of operation which has proven to advantage is that of supplying energy from the storage plants to the Alabama system during peak hours, and during the offpeak hours power is returned from the Alabama system to the Georgia system. This reduces steam plant operation

and permits the operation of flow of river plants at high load factor.

Load dispatching on the interconnected system is quite a simple matter—the principal requirements being close co-operation between dispatchers of the various systems. The Georgia Railway and Power Company being located centrally with respect to other systems usually receives and relays the load orders from the various companies. An effort is made to predict load requirements several days in advance in order to prevent the unnecessary operations of steam plants.

It is, of course, essential that all systems maintain a frequency of about 60 cycles before successful interchange can be obtained. The frequency is in reality controlled by the system supplying the power, and the load swings of the entire interconnected system are shared equally between the systems. The installation of accurate frequency indicating instruments has materially assisted in the operation of the system. Several of the companies have installed at their principal stations frequency devices known as Warren Master Clocks. This clock contains two complete movements, one of which is regulated by a pendulum, and the other is driven by a self starting synchronous motor. On the dial of the clock there are two hands, one of them black and the other gold. The black hand represents the time as determined by the pendulum which can be very accurately adjusted. The gold colored hand is driven by gears from a self starting synchronous motor. This motor, of course, is operated by power from the system, and therefore operates at a speed proportional to the system frequency. The gear ratio between the hand and the motor is such that at normal frequency the gold hand will revolve at exactly the same rate as the black hand, and if started together they will remain so as long as 60 cycles is maintained. An increase or decrease in the frequency will cause the gold hand to lead or lag the black hand. By closely watching the instrument the operator is enabled to maintain an average frequency of 60 cycles.

Another requirement of interchanging power between systems is that of maintaining proper voltage conditions in order to bring about the proper distribution of the reactive current among the several systems. The bulk of the load carried on these systems is at a power factor ranging from 80 to 90 per cent and therefore the total reactive component is rather large. For instance, at 80 per cent power factor the reactive component is 60 per cent. At times it is necessary to operate generators under light load or even no load conditions for voltage boosting purposes.

The application of proper relays on all of the systems is essential in that a line or piece of apparatus in trouble should be immediately disconnected so that the remaining system may be operated without further disturbance.

This interconnection has also proved to advantage in increasing the reliability of service. Line or apparatus failures upon isolated systems naturally cause interruptions to customers. Upon interconnected systems it is most always possible for the combined generating capacity to take care of any reasonable number of failures. This possibility has been well demonstrated by the use of the tie between Georgia and Alabama in emergency cases. The recent severe sleet storm in Northwest Georgia broke down some of the lines west of Atlanta, and the load in Western Georgia was immediately picked up and carried from the Alabama Power Company's system until repairs could be made. Likewise interruptions to customers in Alabama have been prevented by use of the tieline.

In addition to interchange between power systems, benefits can also be derived from the interchange of industrial plant and central station energy. Such interchange to a limited extent, has been accomplished between the Alabama Power Company and Tennessee Coal, Iron & Railroad Company. The latter company generates a considerable portion of its power requirements from exhaust steam of its rolling mill engines and from steam obtained from boilers fired by blast furnace gas which would perhaps otherwise be wasted. By installation of sufficient generating capacity to take care of its base load, a very good load factor can be maintained at its own plant, allowing the peak loads to be carried by energy purchased from the Alabama Power Company as shown in Fig. 5. Surplus energy from the T. C. I. plant is pumped back into the Alabama Power system if desired by the latter company. In Fig. 5 such delivery of surplus energy is indicated by the shaded areas. The operating problems involved in the parallel operation of the T. C. I. plants with the Alabama Power system have been worked out very satisfactorily. In fact this interconnection affords an operating advantage over isolated plant operation in that comparatively more generating capacity is provided for absorbing the characteristic steel plant load swings.

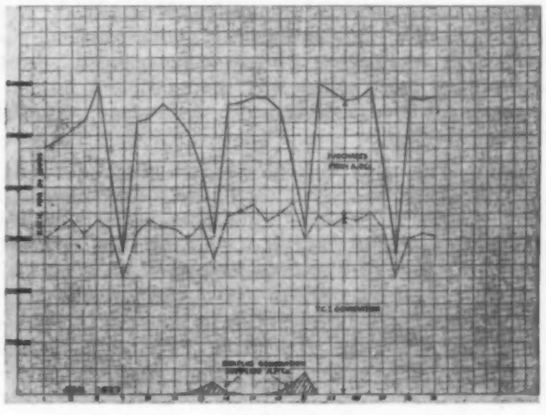

FIG. 5.

Besides steel mills, there are other industrial establishments which can undertake interconnected operation with central stations to advantage. Among such industries would be those requiring heat in the form of low pressure steam in the production of which electrical energy can be generated as a byproduct When more byproduct energy is being generated than required, the surplus could be disposed of to the central station company, and visa-versa when a deficiency occurred the additional energy required would be purchased from the central station.

As the load on power systems continues to increase the benefits of interconnection will become more and more pronounced. To summarize, some of these benefits are as follows: 1—Reliability of service. 2—Reduction of total reserve capacity. 3—Economies due to diversity of stream flow in different water sheds. 4—Economies due to diversity of load factors.

*Electric Mining Equipment, Its Selection, Care and Operation**

By A. F. ELLIOTT†

THE success of an electric mining installation is governed by three principal factors: First, the engineering or selection of the equipment; second, the care with which it is installed; and, third, its operation.

General.

Before correct selection can be made, all of the conditions, facts and data must be carefull studied. Complete survey of the whole situation should first be made and, where necessary, tests should be carried out to determine what the operating conditions will be.

Among the first considerations will be to decide what source of primary power is to be used. Formerly, there was but one choice—namely to install a power plant suitable for the operation under consideration. Later, owing to the more general use of electric drive together with the increasing size and number of mines, it became feasible to construct central generating stations to serve groups of two or more mines. Now we have in most every mining district an independent power service, from which the required amount of power of suitable character may be drawn. The question of generating the power on the property or using purchased power must be solved on the basis of the relative cost of power. Taking into consideration all of the factors, such as new investment required, utilizing equipment already installed, suspended operation due to strikes or other causes, interruptions of service, etc., for the smaller operation, purchased power will usually be found desirable. There is ample reason for this. Isolated power stations are nearly always small and inefficient, and being run as a side issue to the main object of tonnage production, they must of necessity show a relatively high unit cost for the power. Owing to the increased size and extent of mines, together with an ever increasing use of mechanical appliances, the cost of power used in the mines has assumed an important place in the total production costs, and even after the marked saving, incident to the electric drive, it remains a considerable factor, and is worthy of careful study.

Generated Versus Purchased Power.

The question of generated power versus purchased power will depend largely on the cost of fuel. For a coal mining company using any considerable amount of power there is no reason why they should not be able to generate their own power advantageously. This is especially true where a coal washing plant is used to prepare the coal for the manufacture of coke or for other purposes. One inherent principle of coal washing is that as the more nearly perfect the coal is cleaned, the greater will be the loss in refuse. Now if a middle product can be drawn off, the washed product may be improved, and at the same time the loss in the refuse can be reduced. This middle product will of course be of an inferior quality, and it will not bear a high charge for freight or handling. It can, however, be burned right at the mines under stoker fired boilers of correct design and capacity, and thus produce a low steam cost, and at the same time enable a better preparation of the coal for shipment.

Substations.

After the source of power supply has been fixed, comes the selection and location of the substation. There does not seem now to be any excuse for using other than 60-cycle current for mining operations. The size and character of the substation will be governed by the load condition. If the mines require power principally for pumping, hoisting, ventilating, etc., it will be advisable to install transformer stations only, and use alternating current motors throughout. If, however, any considerable haulage system is required and mining machines are to be used, it will be best to install rotating machines to furnish direct current for the motors best suited to that class of service. These machines should be of the synchronous type, except for the very small sizes. It is frequently desirable to use 2300-volt distributing circuits so that the line voltage may be led directly into the greater portion of the equipment without further transformation. Electric drive lends itself admirably to all classes of mining work except that of precussion drills. In that service, compressed air stands supreme. Electric driven air compressors located near the workings will meet this condition beautifully. The substation apparatus is pretty well standardized, and is not unlike a street railway substation except that 275 volts should be the limit for underground trolleys and similar apparatus. The automatic substation has become well established in some industries and its use for mining plants should be extended. However, in most cases it is wise to have an attendant on duty.

The location of the substation can usually be arranged so as to combine with other equipment and thus reduce the cost for such attendance. The substations should of course be located at or near the center of gravity of the load, but whether they are to be located on the surface or underground may be governed by the matter of attendance. In fact, it may be wise to locate for the same mine one on the surface where it can be combined with a fan or hoisting installation, and another be combined with an underground pumping station or other center of operation. When located underground, three conductor high voltage cables are required, usually suspended in shafts or bore holes. Precaution must be taken to prevent creeping of the lead jacket of such cables. Multiple conductor cables are required in all cases where high voltage current is taken into the mines. These cables together with their terminal are apt to be the source of most of the transmission line troubles and should therefore be very carefully installed, and should be avoided altogether where open work will

*Presented at Birmingham Section,

†Electrical Superintendent, Sloss Sheffield Steel & Iron Company, Birmingham, Ala.

meet the requirements for safety. Where long runs of such cable are required underground, it should be sectionalized by suitable junction boxes to facilitate testing and repair.

Motors.

The choice of electric motors for driving the machinery depends in a measure on whether machinery already in place is to be driven or whether complete new units are to be installed. The main hoist engine should be fitted with a.c. slip ring motor with liquid rheostat control. Smaller hoists, 250 hp. and under, may preferably have contactors with grid resistance control. Motors of 100 hp. and under should be fitted with drum controls. Small auxiliary hoists may be either a.c. or d.c., depending on the character of current available. If d.c. is within reasonable distance, straight series motors are to be preferred for hoisting service. All of the important hoists should be protected with automatic overwind, and slow down switches actuated by the hoist mechanism. Crushing, elevating, conveying and handling machinery can usually be driven by squirrel cage induction motors. Careful check should be made, however, to determine what the operating conditions would be, and to make sure that such motors do not have to start under heavy load, do not have to run at variable speed, and are not to be frequently started and stopped. In such cases it is best to use motors having wound rotors and slip rings for rheostatic control. The method of connecting the motors to the machines should be carefully thought out. In general it is good practice to connect large motors through gears with a flexible coupling. Herringbone gears should be used where it is certain that perfect alignment can be maintained. Where there is excessive vibration or possibility of misalignment, spur gears or silent chain drive should be used. It is never advisable to use a pinion directly on the armature shaft, except in the case of back geared motors. Small high speed motors should be belted to the machines they are to drive. Large ventilating fans, crushers, etc., should be driven through leather belts or transmission rope. Silent chain drive usually works out best for elevating, conveying, and similar machinery. The main pumping station should be equipped with centrifugal pumps, direct connected to the driving motor through flexible couplings. The small gathering pumps should be of the piston type for the reason that they usually have to draw the water from several different points, and frequently break the vacuum, and they do not have to be primed in starting as is the case with centrifugal pumps. Single cylinder pumps can be used for low heads, but triplex pumps should be used for the higher heads. It frequently happens that steam and air pumps may be readily converted to electric driven pumps by replacing the steam cylinder with a power end. Such pumps should always be driven through canvas or rubber belts. Automatic starters can be used on the motors provided the voltage is maintained at all times.

Haulage Equipment.

Traction locomotives are to be chosen for conditions where the grade against the loads does not exceed 4 per cent. For heavier grades, some system of motor driven rope haulage will prove to be the more economical. The locomotive should always have steel frames and ball bearing series motors. The wheels should have renewable steel tires for the medium and large sizes. Very small locomotives of 5-ton weight and under usually show lower costs with chilled cast iron or solid steel wheels. All locomotives should be fitted with heat treated gears and pinions. Storage battery locomotives, as now built, are thoroughly dependable, and should find an ever widening field of application. Where underground conditions for maintaining overhead trolleys are adverse, the storage battery is an excellent substitute up to its limitations as to distance and grades.

Coal Cutting Machines.

Coal mining machines are among the very first applications of electricity to mining in any form. For several years only two types of such machines were manufactured—the chain breast machine and the disc long wall type, the former used almost exclusively in America and the latter abroad. The choice lay, therefore, between hand and machine mining. Today there are several makes of various types so that a machine may be selected to meet almost any condition of mining, and while any one of the different types may be used to successfully mine the coal, some have great advantages over others under certain conditions. The controlling factor is frequently found in the mining condition rather than the type or make of machine. There is such a variety of conditions in the mines, such as stratified slate, rock, sulphur, and other impurities in the coal seam, besides the different system of working, that a careful study of each local condition must be made to insure the choice of the best type of machine to use. Usually one type of machine may be found that will be superior to any other for a given condition. Alternating current motors have been used successfully to drive coal cutting machines, but the system is open to several objections, and if a considerable number of machines are to be installed, it will be found best to use a compound wound motor for driving the machines. The mining machines should be fitted with heat treated gears and chains throughout. The most economical cutting speed is found to be from 18 in. to 24 in. per minute. Coal drills, small fans and similar machines having the motor direct connected should be equipped with series motors. Frequently no starting resistance is required for this class of equipment.

Care and Operation.

While the care and handling of electric mining equipment is greatly simplified by the selection of apparatus well suited to the working conditions, it is of prime importance that the equipment have proper care and attention. Certainly it must be carefully installed and set up to insure satisfactory operation. There are many natural conditions in the mines which tend to make this a most difficult task. Probably the most difficult of all is moisture and dirt. Unending effort is required in that direction. First the motor and auxiliary apparatus used underground should be especially treated with a moisture repellant compound of some kind. Stationary apparatus should be installed in the driest location possible and preferably in fireproof rooms if in coal mines, also out of the main ventilating current of the mine. This means, of course, that suitable regulators must be provided to properly ventilate the rooms and prevent overheating of the motors, transformers, etc. Machinery installed in the main air current will tend to sweat a great deal, and besides the air carries acid fumes that are injurious to the insulating material, besides in the event of fire it is apt to become serious. Portable and traveling

machinery is exposed to the very worst conditions; constant inspection and supervision are required to keep the apparatus in proper working order, and this is greatly handicapped by insufficient light and lack of room. The matter of proper lubrication for this class of apparatus is a most difficult task. Diligent workmen are required, and the conditions about many mining camps often fail to attract the best class of labor. Usually it is found more satisfactory to take the local men who are accustomed to mining work and train them to operate and repair the equipment rather than try to get experienced electricians and teach them mining methods.

Organization.

It is not an easy task to organize and train a force of men to operate and care for the electric machinery about a mine. It is used in connection with every department and is inextricably linked up with the mechanical department throughout, thus making it difficult to draw, definitely, the lines of responsibility and authority. Formerly, the electrical department being small and comparatively unimportant, it was subordinate to the mechanical department. Later, as it grew in magnitude and importance, it was made a separate department, reporting directly to the superintendent, and carrying its own line of operators and workmen. This was but little improvement, and besides tends to increase the cost of operation. There is always duplication of effort, overlapping of authority, and division of responsibility, together with some friction. Combination of the two departments makes for the most efficient operation. Since electric equipment is now frequently of great importance, the tendency is to subordinate the mechanical to the electrical department. Experience has shown this to be the best system with traveling cranes, locomotives, mining machinery, and to some extent power stations and substations. This does not mean necessarily that electricians should do mechanical work, or vice versa. Expert and skilled workmen are required in both lines, but they can be directed by and made responsible to one head. The indications are that the electrical men have the preference in that line, and it is to be seen whether they will measure up to the new requirements. Judging from the progress which they have made in recent years in meeting and solving the many problems of electrical work there is every reason to expect success in the combined duties.

The discussion of the article, "Developments in Electric Maintenance Shop Practice," was presented at our Nineteenth Annual Convention and Iron and Steel Exposition and was delivered by the engineers whose names appear below. From time to time additional discussion on this subject will appear in our Iron and Steel Engineer, so in case you have anything to offer which might be of interest to our membership please forward it to us.

Discussions presented by:

W. H. BURR
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N. E. DREXLER
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JESSE L. JONES
Metallurgist, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

A. L. REICHERT
Electrical Engineer, The Bourne Fuller Company, Cleveland, Ohio.

G. A. ROWE
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D. W. BLAKESLEE
Electrical Engineer, Jones & Laughlin Steel Corporation, South Side Works, Pittsburgh, Pa.

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Electric Repair Shop Foreman, Jones & Laughlin Steel Corporation, South Side Works, Pittsburgh, Pa.

A. W. MOHRMAN
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A. HOYT LEVY
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Chief Electrician, Ashtabula Sheet Steel Company, Ashtabula, Ohio.

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ARTHUR J. WHITCOMB
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W. G. COLSON
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W. T. SNYDER
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GEORGE RICHARDSON
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J. A. MORGAN
Superintendent Electrical Department, Edgar Thomson Works, Carnegie Steel Company, Braddock, Pa.

JOHN C. REED
Electrical Superintendent, Bethlehem Steel Company, Steelton, Pa.

Discussion: Developments in Electric Maintenance Shop Practice

W. H. Burr*: An electrical repair shop in the modern steel plant in my opinion should be equipped to take care of all repairs necessary to equipment over which the electrical department has supervision, with but a few exceptions such as repairs to turbo-generator windings, turbo-generators and main mill drives. In order to handle this discussion to best advantage I will simply follow the outline given by Mr. Cummins in his questionnaire.

Our present practice in cleaning equipment received in the shop for repairs is to have the regular department repairman, who makes the changes in the equipment, blow the motors out with air before they are brought in the shop building. This keeps a great amount of dirt from being scattered around the repair shop. In the shop the dismantling of the motors, replacing of field coils, repairs to brush mechanism and leads, together with testing and assembling is all done by one man with a helper.

When motor is received for repairs it is placed in a large metal pan and thoroughly cleaned on the outside with coal oil, it is then dismantled and the armature sent to the armature department. The inside of the frame is thoroughly cleaned with gasoline and the necessary fields are changed and new leads installed. In almost every case the inside of the motor and fields are repainted before the armature is again put in place. The armature is inspected by the foreman of the armature department and tested for grounds and shorts. He uses his best judgment as to whether the winding is in such shape that it can be repaired or whether it is necessary to install complete new winding. After repairs are made on the armature it is returned to the motor section where the armature is placed in position and new bearings installed where necessary. The motor is then given an insulation resistance test, and a running test, usually at light load only, before it is returned to the mill.

We have in our shop at the present time an apprentice system in connection with the Coatesville High School Vocational Training Course. The apprentices work two weeks in the shop and two weeks in school for a period of two years. So far this arrangement has been very satisfactory.

We do not have a set practice with reference to cutting out damaged armature coils and for our conditions I do not think it is necessary. If the windings are in very good condition and the defective coils can be removed without in any way damaging the other coils in the armature it is removed. If not the whole armature is rewound. In cases where failure in the armature would cause serious delay no chances whatever are taken with the armature winding.

Our present practice is to repair the commutator with defective mica segment or V rings in our own shop. Results so far have been very satisfactory although I feel that a factory repaired commutator should be more satisfactory than one repaired in the ordinary steel mill repair shop.

We have no definite data on the saving due to baking and dipping of armatures. Only on rare occasions do we have trouble with armature leads breaking, so that we have no reason to make reinforcements to the leads.

In case of a bent shaft if it can be pressed out of armature it is replaced with a new shaft. If the shaft is otherwise in good condition and it cannot be pressed out of core we attempt to straighten it in an old lathe used for this purpose only. On old type motors where shaft is worn and cannot be pressed out of core we true up shaft and fit bearings to individual armatures. We make it a practice to keep spare bearings on hand ready to bore out for most of our old type motors.

With worn pinions, in extreme cases, the shaft is built up by electric welding, turned and pinion bored to fit. This in my opinion should not be resorted to except in extreme cases as the built up metal is only cast and will not prove as satisfactory as forged steel.

In case of bad keyway if shaft is otherwise in good condition the old keyway is electrically welded and the armature shaft turned 90 deg. and a new keyway cut in the shaft at this point. If the shaft is not otherwise in good condition a new shaft is installed. Only forged steel, heat treated armature shafts are used in our shop.

Personally I feel that factory repaired commutators prove sufficiently superior to the commutators repaired in the ordinary mill repair shop to justify the additional cost, although I have no figures to substantiate this statement.

The purchase of complete commutators mounted on bushings is better practice than to purchase assembled bars. Where segments are purchased assembled quite frequently it happens that the V rings do not fit the commutator segments properly and unless great care is used the V ring is damaged when the commutator is assembled.

To a certain extent the answer to the last two questions depends on the equipment in the shop where repairs are to be made.

We make it a practice to slot all our commutators where we have trouble with oil and fill these slots with commutator cement. Oil and acid proof paint is used on the end of commutator segments and around string bands on the armature. A decided improvement has been noticed in trouble due to oil since this practice has been followed.

Not only do high grade brushes increase the commutator life, but also, the length of life of the winding, as poor commutation causes over heating of the entire motor.

In rebabbitting bearing shells it is not always necessary to clean the shells, but it is certainly advisable if you wish to obtain a maximum length of service from the bearings.

One man does all the babbitting work in the shop and uses extreme care in handling babbitt. I believe that a pyrometer outfit would enable the men to handle the babbitt more intelligently and justify the additional investment.

From our shop records I find that all our modern type mill motors and modern industrial motors which are fitted with sleeve bearings give practically no trouble due to the throwing of oil. We have not had sufficient ex-

*Electrical Superintendent, Lukens Steel Company, Coatesville, Pa.

perience with anti-friction bearings to enter into this discussion in any way.

If a steel mill repair shop has enough work to warrant the installation of a repair department with equipment on a par with service stations maintained by large electrical manufacturing companies it is perhaps advisable to make some of their own coils. On modern mill type motors I do not believe that any steel mill repair department is in a position to make coils which compare with original coils furnished with the motor.

Ordinary hand starters and manual controllers, in my opinion, should be overhauled only by men in the electrical repair shop. It is our practice to have all this work done by one man who devotes his entire attention to this work. In the shop facilities are better for making the repairs.

Automatic control except in extraordinary cases can be repaired by a specially trained mill repairman. If the control is to be completely overhauled we make it a practice to take the controller to the electrical repair shop and completely overhaul it and test this as far as possible before it is returned to the mills. It is tested for grounds, and wherever possible, for sequence of switches, and in most cases actually connected to a motor and tested before it leaves the shop.

We feel that standardizing resistance is by all means advisable. If the control is furnished with resistance which does not conform to our standard it is put in operation and as soon as it is necessary to be repaired new resistance of the standard type is installed. We have a standard 5 in. grid used on all small work, a standard type grid used with manual controller, and a standard type grid with automatic controller.

Our substation is fitted up with tools so that the substation operator makes minor repairs to controller drums and controllers used in our open hearth department. This results in a certain saving of time in getting repairs made as the substation is located in the open hearth building.

In checking up on our electrical equipment I find that at the present time we have installed 754 motors, total hp. 17,629. Our inventory of armature coils at the present time shows 144 sets of coils. Whenever possible new motors are purchased which are duplicates of those in service which aids very materially in cutting down the total cost of spares.

N. E. Drexler*: While the service conditions on electric railway motors are slightly different from those on stationary motors used in factories and mills, there are a number of points of similarity and some of the practices in use in electric railway shops are applicable to industrial motors. This is particularly true in regard to d.c. motors of the heavy duty type.

Armature Repair Practice

In making armature repairs it is often necessary to repair for open circuits. To do so, if the coils are not dried out or brittle and if the armature has not been dipped and baked, it is frequently possible to replace the damaged coil without rewinding. In cases of armatures which have been dipped and baked this procedure is not possible, but the armature can be made serviceable for a long time by installing a jumper to eliminate the open circuit.

Dipping and baking railway motor armatures for the past five years has cut down numerous minor troubles and has clearly shown that the practice is advantageous. The only objection, which is of little consequence, is that it is more difficult to remove old coils before rewinding.

The practice of dipping and baking is as follows: After the armature is rewound it is dried out in the bake oven for a period of 10 to 12 hours. While hot it is immersed endwise in a tank of Westinghouse amber baking varnish for about 15 minutes or until bubbles cease to rise to the surface. It is then raised out of the tank and allowed to drain until the excess varnish has been removed, after which it is baked at a temperature of 100 deg. C. for 72 hours. It is highly important that the excess varnish be removed by proper draining. If this is not done a certain amount of it will be thrown out against the pole pieces when the armature is again put in service. Furthermore, the surplus varnish will accumulate at the lower side of the armature (when baked horizontally), throwing it out of balance.

Shafts, Journals and Keyways

Our experience has been that most bent armature shafts are caused in removing the pinion by wedging or driving off. This trouble was eliminated by the use of an Electric Service Supplies Company's "Peerless" hydraulic pinion puller, the jaws of which encircle the pinion, thus causing a uniform pressure to be exerted. This puller is powerful enough to remove the most obstinate pinions.

After having tried bushing as well as welding and turning down armature journals, we have come to the conclusion that the best practice is to turn down worn journals to a smaller size and when they reach a certain minimum diameter replace them with new shafts. Our practice until recently was to bush them, but the large number of failures of bushed shafts has discouraged this method.

In regard to bad keyways, our practice is to fill them up with the electric welder and cut a new keyway. We do not believe in welding up worn pinion fits, however, for the same reason outlined above for worn journals.

While the above discussion is based on results obtained on the Newport News & Hampton Railway, Gas & Electric Company, it is believed that the adoption of some of the practices described may be of value to steel mill electrical repair shops.

Jesse L. Jones*: This discussion is confined to the six question listed under Section (g) of the paper, viz.:

1. What is the permissible radial wear in d.c. armatures?

This would depend upon the type of machine, air gap, etc. In 2,000-kw. machines with a double air gap of 5/8 in. or 5/16 in. on a side, a wear of 1/8 in. might be permissible.

2. What is the permissible radial wear in induction rotors?

No very definite answer can be given to this question, either. The air gap on large rotors is from 1/8 in. to 1/10 in. on a side and the only safe procedure would be to measure this gap at regular intervals. Uusually the wear is very slight. In the case of one rotor fitted with lead-base babbitt bearings that has been in service in a rolling mill for 20 years, a wear that was almost negligible was found.

3. Have you found any quick way to inspect bearings for radial wear that is dependable?

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*Metallurgist, Westinghouse Electric & Mfg. Company.

Wear is always greatest on the bottom half of a bearing. Measuring the air gap when a machine is installed and subsequently at regular intervals is a reliable method of inspection.

4. In rebabbitting shells, is it always necessary to first tin shells as recommended by manufacturers?

Tinning is very essential. Shells should always be tinned with wiping solder which has a low melting point and a long melting range. The solder should be still dripping when the shell is babbitted, in order to assure the proper adherence of the babbitt. Tinning with babbitt is possible, but its melting point is so high that it sets before the shell can be put in position on the mandril and when poured, a loose lining results, the only adherence being where the stream of babbitt strikes the shell continuously.

5. Do you use any especial care in handling babbitt? If a change in babbitting has recently been made, have you noted any superior service? Does pyrometer equipment actually enable babbitt men to do enough better work to justify the investment?

If either a lead or tin base babbitt is heated much above 500 deg. C., considerable antimony is lost by volatilization. However, more bearings are spoiled by underheating than by overheating. Unless a fairly high temperature is maintained, the copper, antimony and other hardening metals of the babbitt are thrown out of solution, skimmed off as dross and a soft, unserviceable bearing results. A range of between 460 deg. C. and 482 deg. C. will be found to give good results with most babbitts. The mandrel should be heated to 100 deg. C. to 125 deg. C. A very fine grain in a babbitt lining is desirable and this depends more upon the rate of setting than upon the temperature at which the metal is poured. The water-cooling of mandrels may be resorted to in order to assist in obtaining the proper grain in the babbitt lining. The use of very thick linings, of anchor-holes or dove-tails and of peening is undesirable.

There are no recent innovations in babbitting that are of especial value. The centrifugal babbitting of bearings has aroused considerable interest and in the case of solid shells, Diesel engine bearings, etc., it has proved very satisfactory. It requires considerable equipment, but can be carried out by unskilled labor. The babbitting of half shells and shells containing lubricating windows by this method offers certain difficulties.

A pyrometer equipment is desirable, but not essential. With an unskilled man who does not babbitt regularly, a pyrometer is useful. A skilled man can judge the temperature of the molten babbitt closely enough by stirring it with a pine stick or by observing its fluidity.

6. Do modern babbitt bearing designs eliminate oil from armatures? What does shop observe?

Present bearing designs are generally satisfactory. Oil troubles in the past have often been due to poor adherence of the babbitt to the shell or to large blowholes next to the shell that were not visible after machining. This allows the oil to accumulate between the shell and the babbitt lining. When a motor with such lining is started up, it often throws out a spray of oil that may cause considerable trouble.

A. L. Reichert*: 1—Coal oil and gasoline are most generally used. Steam is used on motor frames, etc., that have grease dirt.

2—Inspection of all apparatus to see just the nature of the trouble. Why and how it happened? And to decide the nature of repair that should be made. This to be decided by the repairman and if very difficult the foreman will decide.

3—Yes, I do. But up to the present we have not made running tests on all equipment.

4—We have never had an apprentice system, figuring we were not large enough to warrant it.

Armature Repair Practice on D.C. Equipment

A—We have never kept any definite data. But have found by experience that not all armatures with one or even two coils, it was necessary to rewind except if an armature was very bad and old.

B—Damaged commutators we feel we can repair just as well as to send them to the factory. We do not have the necessary shop equipment for a new job as we usually buy filled commutators from the manufacturer.

C—We do not have a baking and dipping process for our armatures at present. I would be glad if we were so equipped that we could dip and bake them.

D—No, we have not adapted any way from preventing the breaking of armature leads in wire wound coils as we do not have any to break.

E—With reference to shaft in the following:

1—Bent shaft we usually put in a new one.

2—Worm journals we try to weld but they have not been so satisfactory.

3—We try to weld them.

4—Bad keyway we weld them.

Commutators

1—I believe factory commutators do prove sufficiently superior to justify the additional cost.

2—We most always just buy the assembled bars and use our old bushing.

3—We use what is called comulac to delay the deterioration of commutator insulation.

4—Not where we can keep oil and grease out of the motor.

5—We think that a good high grade of brush does help wonderfully.

Bearings

1—Permissible wear for d.c. motor bearings to about .010 in. or .012 in.

2—Induction motors allow to wear down to .008 in. then they should be changed.

3—We usually use a feeler sometime where it is possible we hold a light on one side and use the eye for the gauge.

4—I believe it should be. We do not do the babbiting ourselves.

5—No, I do not believe we do. The mechanical department does it all; they do not use any special care and do not use any pyrometer.

6—We do not have any of the so-called leak proof sleeve bearings so I could not say.

Anti-Friction Bearings

1—We have never had any occasion to take one off yet.

2—I do not know from experience what their life should be. Greasing should be done by one man at stated intervals.

3—Have not tried them long enough to find out.

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Coils

1—To make their own coils depends on the size of the company and the number of repairs made. I do not advocate doing so.

We do not dip or bake.

Third A.C. Stator Practice Cores

A—We have not had to do any restacking.

B—To prepare cores for winding is to clean and file.

C—We have never had any trouble with either type lamination we have about 450 a.c. motors.

Winding Practice

A—Consists of fish paper in slots.

B—Consists of oil linen and tape.

C—We buy our coils.

D—We do not have any special method.

Rotors

A—We find in most welding, rotor bars have proved most satisfactory.

B—We put insulation in as originally designed.

C—We have very few wound rotors.

D—No, there is no reason why dipping and baking are not desirable in wound rotors.

Controllers

A—Controllers should be repaired by shop men whenever possible because they become more familiar with all types and as a rule it is a better place to do it and is usually accessible to more tools and material; complete overhauling is usually made.

B—They are most always tested out on some motor unless it is a minor repair.

C—I think resistance should be standardized but as yet we have not done anything.

D—We do not have any special stunts for controller repairs.

G. A. Rowe*: I consider all the points mentioned by Mr. Cummins to be of great importance in shop upkeep. I am very glad to be able to discuss such of these points as come within the scope of my experience, from the standpoint of a shop foreman.

Shop Cleaning

As a rule, all grease, oil and dirt are cleaned from jobs when they are received by the use of a good grade of gasoline. If the trouble is not apparent, a voltage test is used for detecting grounds, and a bug test for shorts.

Where there are a large number of the same type of motors in service, a running test is advisable before the motor is replaced in service, after repairs have been completed in the shop. However, in steel mills this is impossible, as it would require an excessive number of spare motors.

From my own experience I would say that the apprentice system is a success, where the foreman is permitted to choose the boys to be trained. Several of the boys from our shop who have taken this training have proved to be very efficient shop men.

When large strap wound armatures are received in the shop, only the damaged coils are removed and replaced. In the case of wire wound, and dipped and baked armatures, all coils should be removed. However, if the time element is an important factor, damaged coils can be cut out of the circuit and the armature placed back in service, where it will often operate for some time without giving trouble, where the number of coils cut out is not large.

Good equipment is essential for the proper repair of commutators, and if a shop is well equipped with a good press, and an efficient heating furnace, I believe repairs can be made more cheaply in the shop. Good material is also an important factor, and only first grade mica bond should be used. This commutator repair department should preferably be located in a separate room. Under these conditions it is undoubtedly more economical to repair commutators in your own shop.

The inauguration of a dipping and baking process frequently results in an appreciable decrease in the amount of maintenance required for armatures, but it should be borne in mind that care should be taken in the repair of the armature, as after an armature has been dipped and baked it cannot be repaired except by stripping the coils down to the core, and rewinding. It is especially important that armatures that are dipped and baked should have good bearings, as bad bearings are a frequent source of trouble.

Broken leads are the result of lack of care in the assembly of the motor, and as a rule are caused by loose laminations, loose commutator, or a loose shaft. In small windings broken leads may also be caused by motor repairman driving leads into cups too hard, or not using the proper drifts.

Commutators purchased from the motor manufacturer are more satisfactory than those furnished by jobbers. Commutators should preferably be purchased complete with spiders, as our experience has shown that if the commutator and spider are changed together, the commutator will give longer service and is not so apt to become loose.

The commutator cement which we have found to be most satisfactory is one composed of plaster paris and dextrine, mixed with a good grade of shellac. Best results have been secured by painting the front V ring of the commutator and eliminating the use of tape or cord.

Undercutting of commutator is effective only when grease and dirt can be kept away from the commutator.

The use of high grade carbon brushes is economical when the saving in wear on the commutator and the longer life of the brushes are considered.

Bent shafts are a frequent source of trouble in motors, and if an effective means of straightening them is utilized, considerable saving will result. A good press is best for straightening bent shafts, but if this is not available a heavy lathe, of the proper size and strength, will be satisfactory. A lathe is used at Duquesne for this purpose.

Worn journals, pinion fits and keyways can be electric welded and turned, which will result in a great saving in labor and material.

Our experience has shown us that the commutator and winding of an armature equipped with antifriction bearings is much more free from grease than an armature equipped with even the best grade of babbitt bearings.

Where the facilities are good, it is unquestionably better practice to make the armature coils used in repairing motors, as slight irregularities in factory made

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coils frequently occur, resulting in loss of time, which is an important factor in steel mill repair jobs. The coil winding department should be located in a room independent of the armature winding department, where there is sufficient natural light, to avoid the necessity of using artificial illumination.

A.C. Stator Practice

New laminations should be installed when laminations have burned together, even if it is the case with only one or two slots, or when the lamination is worn to such an extent that the wedges cannot be held in their proper place. Most lamination trouble is caused by low bearings. In case of open slot winding, the stator should be dipped and baked. In semi-open slot stator, however, baking and dipping should be dispensed with, as repairs to motor cannot be made after it has been baked and dipped, in case of ground or short.

Rotors

Welded squirrel cage rotors and rings are superior to bolted or soldered rings, but cannot be repaired. We find bars in slots are as satisfactory without insulation as with insulation provided bars are tight in slots and welded to end rings.

Control apparatus should be repaired, if possible, by the mill maintenance men, which gives them a better working knowledge of the apparatus and tends to make them more careful in its use if they are responsible for all repairs.

Resistance banks should be standardized. We have reduced our storeroom items 60 per cent by building all our resistance banks from a few sizes of grids. Our method of handling this has proven very satisfactory. Each mill foreman has a set of about 100 resistance sketches, which covers practically all the requirements of the 1,000 motor drives in our mills. In ordering resistance banks the mill foreman is required to give full motor and control data, as well as resistance required on his order. This must be checked and approved by the electrical engineer before going to the shop. In this manner the correct resistance is always used, for which the shop and mill foremen have the data, and for which spares are always available.

The number of spares to be carried for running armatures is difficult to determine, but the general rule is that where lack of spares will result in curtailment of production, the largest number of spare armatures are provided, and in places where this is not the case a smaller number of armatures will be carried, and in some places spares are not carried at all. This ratio is generally 4 to 1 in the most important places, 2 to 1 in the less important departments, and 1 to 1 in others.

D. W. Blakeslee* and A. W. Boley†: (a) Motors: Scrape off grease and dirt, then clean thoroughly with waste dipped in torch oil, paint with black finishing varnish. Strap Coils: After removing them from armature, boil in water, this will soften the varnish and insulation and permit the copper to be cleaned properly before being ready for reinsulation.

(b) Upon receipt of equipment for repairs it is tagged, carded, and entered in ledger. A visual inspection can determine the trouble and what repairs must be made. If the item has been previously repaired, a check for its serial number on the record cards will show who did the work, and length of service of item. An electric department order is made out for repairs, giving all the required information; such as: Quantity, type, serial number, date received, charge account, where from, and requisition number. From this order a printed red tag, 3⅛ in. x 6⅜ in., is written up with order number, date received, charge account, where from, type volts, serial number, horsepower, winding, connection, coil number, and remarks. This tag is attached to equipment and remains with it until it is taken out of the shop. Then the destination and date taken out are written on the other side of the tag, and entry made in the ledger. A printed card is also made out: For example, if the item is an armature, the following is recorded, order number, type, serial number, where from, work to be done, material used, commutator repair, wind and connect, insulating, banding, turning, miscellaneous. Each man fills out a time sheet which shows: Date, order number, serial number, hours, charge account, work done, what new or old parts used. Record card is more fully written up from the time sheet, then filed.

(c) Too many different sizes and types cause it to be impossible to make running tests of all repairs and equipments. Voltage tests for grounds and shorts, and growler and 'phone tests prove very satisfactory. All armatures are tested thoroughly while winding with 2,000-volts for grounds and short circuits, and after banding and finishing, with 1,500-volts.

(d) It has been found successful to hire inexperienced young men, (and older ones) of good moral character and steady habits, who have homes in the vicinity, are interested in the work, and desirous of learning in order to get better pay. They are taught the work, and in most cases stay for years. On armature repairs they start at helpers' rate, from where they advance to fourth class winder, then third class, second class, and first class, each advance giving an increase in wages. If a man is incapable of advancement he is tried on other work; if then found deficient, dismissed.

Armature Repair Practice, D.C. Equipment

(a) Occasionally an armature arriving at the shop with one or more coils burnt out can be replaced without complete rewinding, but not very often. Usually the coils are dry, brittle, too tight in slots, old or greasy and have gone through one winding; one or more coils can be changed if coils on armature are flexible and in good condition. The best practice is to remove all coils, select the best ones and rewind. When reinsulating strap wound armature coils, first boil them in a tank of soft water to soften the old insulation and varnish, this will make it easy to remove; after removing the insulation, file off any sharp edges, tin the ends that fit into the commutator bars, insulate the front ends of coils with linen finish tape lapped half. The mica cell around the coil must be wrapped tight with linen finish tape edge to edge, and have no air pockets after coil is finished. After coil is dipped in varnish, dry thoroughly and retin again. Paraffin coils before placing in armature. All strap coils of larger sizes are reinsulated in the mill electric shop.

(b) It is more economical to repair commutators at the mill armature shop than to send them outside for repairs. When repairing the larger commutators that have not been disconnected from the armature coils, the following has been found to be a very good method for loosening or tightening the commutators: On the rear

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end of armature shaft key on old pinion or bushing, to provide a grip for a chain wrench to hold the armature from turning. On the commutator end use a flanged bushing, made for that purpose with four holes to correspond with those in the commutator nut; pin in position and turn with a 48 in. Stillson wrench, with extension of pipe for longer leverage. Heat commutator to soften mica rings, then tighten. When it is tight a tap with a hammer will produce a ringing sound. One flanged bushing with suitable arrangements of holes can be used for many different sizes of armatures. Hammer and chisel should never be used to take off or put on commutator nuts.

(c) If an armature is wound with a set of coils that have been dipped and baked, it is only necessary to give that armature a coat of black varnish; this applies to mill and railway type motors used on mill applications and shop equipment. Hand wound armatures and those wound with mush coils should be put through the dipping and baking process to keep the windings intact, to prevent creeping, and to make oil proof.

(d) Breaking of leads in certain types of armatures with spiders held in place with ring keys is caused by end vibration of armature core wearing down the ring keys. This causes the armature core to loosen and a general vibration occurs, breaking off many of the leads to the commutator. Remedy: Discard the ring key, make new spider with nuts to hold in place. The trouble is then eliminated.

Broken wires are sometimes caused by nicking them when driving into commutator slots, or in skimming the insulation from the leads. To prevent vibration of the leads, tie or tape down tightly all bottom leads. Top leads should be stretched tightly and no slackness permitted in any lead. Top and bottom lead will move back and forth while armature is rotating if not held rigid. This movement will in time break the lead.

(e) 1. Bent shafts, up to the largest sizes in the usual mill applications, are straightened in a screw press without being removed from the armature. The straightening can be done without damage to the armature or commutator.

2—Worn journals are built up with an electric arc, the elctrode used is a small rod of 60 to 80 carbon nickle steel. The use of such a high carbon permits the burning out of eight or ten points and still have the deposited metal of a higher carbon than the original shaft. The armatures are sent out equipped with bearings.

3—Pinion shafts are treated in the same manner as are the worn journals.

4—Bad keyways are treated the same as journals and pinion fits.

(f) 1—Factory commutators prove superior enough to justify additional cost. These commutators are made from hard drawn copper, which is much better than any hot rolled, cast, or forged bars; they are true to gauge, the mica is of the best quality, perfect fit, and can be depended upon for good service.

2—Assembled bars should be purchased not mounted on bushing, unless a new bushing is needed, which is seldom the case.

3—The writers do not know of any oilproof paint or cement that will prevent commutators from accumulating oil or grease. As stated above; plaster of paris mixed with water and put between the bars after undercutting has proved effective. A commutator grounded on the front end can be repaired by cleaning thoroughly so as to remove all carbon deposits from pits and cracks: then press into the places to be filled asbestos crumbs and shellac; dry with a blow torch. Such filling will not come out, and will save using expensive commutator cement.

4—Any application of a motor in a damp or oily atmosphere is undesirable for undercut commutator, because of tendency of deposits to stick between the bars and short circuit them. Plaster of paris between bars on all applications may be used with performance.

5—Brushes should be suitable for the application. The brush manufacturer can best specify the brush to use as determined by current density, commutator speed, etc. It is a needless expense to use a higher grade than is necessary.

(g) 1—There is a big difference in the air gaps of the old and new types of motors, therefore, the amount of permissible bearing wear cannot be fixed to any given dimension for all motors, but should be governed by the type and size of motor being considered.

2—A quick way to inspect motor bearings for radial wear is by the use of a pinch bar and fulcrum to lift the end of armature shaft while in motor.

3—All bearing shells to be rebabbitted should first be retinned.

4—It is believed that the regulation of babbitt temperature by pyrometer produces results which justify the investment.

5—No babbitt bearing in motors in the usual iron and steel application have been found which will stop oil from creeping along shaft to coils and commutator.

(i) It is not advocated that the electric repair shop should make its own coils. The manufacturer is in the coil making business, and where he makes thousands, the repair shop would make but a few. He gets larger discounts on all materials he purchases on account of buying in large quantities, probably by the carload; the shop would buy in small lots.

The manufacturer is constantly using his material, some of the repair shops might lay in stock for years. He has the advantage of an up-to-date shop, equipped with all modern devices, such as winding and tapping machines, impregnating and dipping outfits, baking ovens, and all other necessary tools.

It is necessary to employ female labor on a piece work basis. Girls are reliable, capable and permanent. Boys and men want to be changed around to get higher pay. The manufacturer is in a better position to handle the required labor.

Different sizes of forms for winding strap and other coils must be made or purchased and stored until needed, all of which is expensive for the iron and steel shop.

The manufacturer makes coils uniform in size. His is a real coil; others would only be an imitation, unless made under the same process. On account of so many different types of armatures it would be unwise for the repair shop to try and make all its own coils. Of those of one type, one or two dozen sets might be needed in a year. There are some types which would be impossible for a mill shop to make. In buying all the coils from the manufacturer you get better service and liberal discounts. It is bad practice to buy coils from different makers, as they would be made on forms which might vary in size and not be interchangable.

Controllers

(a) If the electricians and helpers in the mill are capable, the controllers should be repaired by them during spare time. If they are not, the repairs should be made in the shop.

Final

(a) Having standardized equipment would help keep supplies to a minimum. Manufacturing concerns carry large stocks of supplies for their customers in their factories and warehouses. If they know that all supplies are purchased direct from them they will keep enough spare parts on hand to fulfill all needs in case of emergency, and deliver them by express or motor truck. This applies not only to the latest improved equipment but to older types as well. This solves the problem of carrying large stocks; although it is necessary to carry some parts.

(b) The amount of spare armatures carried depends upon the applications, class of operators, class of maintenance men, number of motors, etc. This is an individual problem.

A. W. Mohrman*: It is the writer's intention to convey to the members of the Association of Iron and Steel Electrical Engineers the results of a survey made at various plants and shops throughout the Cleveland Section. This information is to answer the various questions compiled by Mr. Cummins.

You will allow me to briefly explain that this information does not come from users in the steel mill, but from various service repair shops, railway and factory, and electric shops.

First. General motor repair shop practice, throughout this section, differs greatly in respect to handling. Some are elaborately furnished with equipment; some with only a few hand tools and a lathe, but in each case it was found that a dip tank and bake oven were installed. Some baked the entire armature or machine, while others only dipped and dried coils.

(a) Cleaning of equipment was, in most shops, effective. Some dry cleaned; some used compressed air; some used boiling water or steam; while others used compressed air combined with a vacuum system. As to economy, the writer did not obtain figures, but the results seen were that a combination of compressed air mixed with gasoline carried off by a vacuum system did the best work.

(b) Inspection and test of equipment, brought in for repair, consisted of a test in the grouler and a line test to determine the trouble, such as shorts, opens or grounds. The milli-voltmeter, in the case of rewinding an armature, the data consisted of measurement of wire; various dimensions of coil to pattern the new coil; number wire per turn; number of turns; connection and coil throw; number of slots; number of bars; throw of leads; coil insulation, slot insulation and band wires.

(c) In most cases a running test of repaired equipment, with a prony brake or dynamometer lead, was considered as a final test. In addition, the high voltage test in most cases of twice the voltage of the machine plus a 1,000 volts for insulation assurance.

(d) Apprentice system does not seem to be in favor in the Cleveland section. In the majority of cases, the workman is brought up through the line according to his ability.

Second. Armature repair practice d.c. equipment is somewhat varied in the different shops visited because conditions are varied owing to the product manufactured.

(a) The feeling in this section is that when a defective coil shows up in an armature, the coil is either replaced, repaired or cut out, i. e., providing the condition of the rest of the armature is good. The writer found several motors with coils cut out that have been operating successfully for the last three years, and other places where they only last two to three months.

(b) Damaged commutators seem to be successfully repaired at mill shops, that is, up to a certain point where it is best for the manufacturer to be called in and make the repair. One repair shop casts their commutator bars, cut mica to fit and assemble, and claims economy, but most have spare commutators, of a size to fit motors, on hand.

(c) As a matter of service obtained by the adoption of the dipping and baking process, no figures were obtained, but the method of dipping varied to such an extent that it would be impossible to say which method would be best. At one shop the armature was rolled in a pan while the varnish was at a temperature of about 85 deg. F. The armature had been preheated for 10 hours and then allowed to drain and was replaced in an oven to bake. A temperature of 250 deg. F. for 24 hours had been used, until recently, the temperature was lowered to 220 deg. and baked from 48 to 54 hours. This gave the varnish a better life. Another shop dipped the armature in the varnish up to the back of the commutator and allowed to stay there until all air had disappeared. The varnish was not heated, only the armature was preheated to not over 220 deg. F. for 8 to 10 hours. The heat of the armature causes the varnish to run freely, then the armature was baked in a heat that was about to the boiling point of water, while a piece of good writing paper was dipped into the varnish and placed in the oven with the article to be baked. At various times the paper was bent, and when the varnish became so hard that it would crack, then the article was taken out.

Still another point in insulation was the kind that gives the best results, as insulating varnishes are divided into two classes:

1—Those which dry by simple evaporation of the solvent.

2—Those which after the elimination of the solvent hardened by reason of chemical change.

These classes fall into two colors, clear and black, and these are again classed into two groups, air dry and baking. In some shops the equipment is dipped, baked and then given a coat of air dry. This, it is claimed, gives the insulation a maximum flexibility and elasticity or gives a tendency to soften under heat but not to such an extent to cause flowing or throwing out. In most places, the air dry was sprayed, and where no ovens were procurable the coils were heated by passing current through them.

(d) The writer found no means of preventing breaking armature leads, as most armatures are wound with heavy wire, only in the case of small fractional hp. motors, which it seems are built up at the manufacturing shops, and are usually sent back for repair.

(e) 1—Bent shafts seem to be straightened in almost every case in the armature. Sometimes the shaft must be removed. This depends to what extent the shaft is bent and where the bend is.

2—Worn journals are built up by electric welding and machined to size in lathe. The same holds with ends where pinion fit also keyways.

(f) The tendencies are that a complete commutator, as a spare, is the thing to have, as these com-

*Electrical Department, Otis Steel Company, Cleveland, O.

mutators are made at the factory and are superior to any that can be built in a mill shop.

(g) The wear of bearings seems to be a part of the operating engineer's views. Some allow all the air gap will stand, while others only allow the wear to a determined point in the air gap. Most of the inspectors inspect air gaps in motor and determine the bearing wear, while others test the slop of the bearing with a block and bar. Tinning the shells does not seem to be favored as much as dovetailed grooves or holes drilled to hold babbitt. A good babbitt seems to be the best paying factor in bearings.

(i) The electric shops in this section all advocate making their own coils and store only the size wire needed. Some have one set of factory coils, and some only make the coils when the job comes in. They have coil winding machines varying from home-made to standard factory make.

Conclusion. The fact that an electric motor will continue to operate under extraordinary conditions of dirt, moisture and oil does not mean that the average motor should be expected to do so regularly. Dripping from water and steam pipes; sweating in a saturated atmosphere or even damp air have an effect on the insulation.

Continued vibration will cause the toughtest steel to give way; therefore, copper and insulation should not be expected to stand up.

Dust and dirt will clog the air vents, causing increased heating. If of an acid nature, or if it contains sulphur or other substances which react with water, breakdown is almost inevitable.

A feeling of pride will keep down maintenance cost, i. e., by lighting dark corners, and the use of paint freely. We may build good motors, but their life depends upon maintenance.

A. Hoyt Levy*: Question—In rebabbitting shells, is it always necessary to first tin shells as recommended by manufacturers?

Answer—It is not absolutely essential to tin a shell, but it is most advisable to do so if for no other reason than that by tinning the lining will hold more securely to the shell and a loose lining will invariably heat.

We have found that in a number of instances where the bearing ran hot, the trouble was primarily due to the fact that the lining, in places, was not tight to every part of the back. A loose lining will, by its motion, create a suction that will draw away the oil-film and so bring the babbitt in direct contact with the shaft, generating a friction that heats the bearing.

Loose linings may result from several causes. Loose anchorage may be one cause. Anchors may not hold because the anchor-holes were not completely and thoroughly cleaned; a bit of oil left in an anchor-hole will not permit the babbitt anchor to tighten in the hole. A film of oil may have been accidentally left on the shell; if the babbitt is of a brittle character and cracks even slightly, oil will work its way through the cracks and under the lining if the shell is not tinned, and so close the clearance and force the lining against the shaft. The importance of cleaning the shell thoroughly, before pouring, and making sure there is no oil whatever on the shell or in the anchor-holes, can not be over-estimated.

*United American Metals Corporation, Brooklyn, N. Y.

Question—Does pyrometer equipment actually enable babbitt men to do enough better work to justify the investment?

Answer—There is no question of the value of a pyrometer for babbitting, but I am inclined to believe that it does not justify its maintenance cost. Men accustomed to heavy work are not often capable of handling the pyrometer with the care demanded by this sensitive instrument. Babbitting is frequently done in places where heavy weights are handled, causing concussions, vibrations and shocks that affect the accuracy of the instrument. I would recommend that thermometers be used instead of pyrometers. A pyrometer may get out of order and register an inaccurate temperature with no visible evidence that it is inaccurate. A thermometer will either register correctly or not at all. It will of course break like any other piece of glass, but its cost is about half the cost of a pyrometer. It will not register as high a temperature as a pyrometer, but rarely does a babbitt require anything higher than 800 deg. F., and most babbitt thermometers register to 900 deg. F.

It is very important that babbitt shall not be overheated. While there are some men who can, by reason of long experience with a certain grade of metal, judge the metal's temperature from its appearance and from the "feel" of the heat in the pot, there are few who can with certainty come within 50 deg. F. of the temperature. An overheated tin-based babbitt becomes brittle and porous and is liable to crack when the bearing is subjected to shock. If poured too cold, the flow will not be sufficiently free to fill the box—it solidifies too quickly and as a result will contain blow-holes which will weaken the bearing.

Once a babbitt is overheated it will never fully regain its lost property. This overheating is not necessarily done when the babbitt is being melted for pouring the lining. The damage may have been done by the babbitt manufacturer who, in a desire to lower the cost of manufacture, quickly melts the constituent ingredients at a high heat regardless of the effect on the properties of the metal. This is all the more dangerous because the loss of ductility caused by overheating does not change the appearance of the metal and cannot be determined by chemical analysis.

It may not be amiss to emphasize here the importance of properly alloying a babbitt.

Alloying is mixing, but mixing is not alloying.

Babbitt metals are made of tin, antimony, copper and lead. High genuine babbitts contain only the first three of these metals. Each of these metals melts at a temperature widely different from the others. It takes 1,981 deg. F. to melt copper, 450 deg. for tin, 1,166 deg. for antimony and 621 deg. for lead. There is also a wide difference in their weights. A cubic foot of lead weighs 710 lbs., and a cubic foot of tin weighs 460 lbs.

Toughness and ductility are two important properties of a babbitt. Both tin and lead, when overheated, lose toughness and ductility. The easiest way to make a genuine babbitt is to put the metals in a pot and heat them to the high point that it takes to melt the copper. Then, when it is all melted, the metals lie in the pot in the following order: the lead at the bottom, next copper, next tin and on top antimony.

To simply stir these layers of varied weights with a ladle, is something like trying to mix oil and water,

except that it takes a mighty husky muscle-bruiser to handle this mass. As soon as he lets up, the several metals begin to settle back to their old positions. Usually the metal-mixer times his stirring by the condition of his arms; when the arms tire, the babbitt is sufficiently mixed.

The scientific method of alloying is to so melt the constituent metals that none of them will be overheated, and to so mix them that every grain will be almost identical in composition with every other grain.

To mix the metals to homogeneity takes hours of constant agitation. Unless the babbitt is mixed to a homogeneous state, hard-points are liable to form by a combination of antimony and copper or by the segregation of the antimony. One of these hard-points reaching the contact surface of the babbitt can do a lot of damage to the shaft.

It is a regretable fact that many of the larger companies buy their babbitt solely on specification—so much of this, so much of that and so much of something else. The alloying is not taken into consideration. The order goes to the lowest bidder. It goes without saying that the bidders, to stand any chance of getting the order, must figure on the lowest manufacturing cost and, wherever possible, on the use of scrap metals, which in all probability had been overheated time and again in previous manufactures.

It is not to be inferred from this that babbitt manufacturers are dishonest or unscrupulous. As a general rule, the babbitt buyer who specifies a formula and orders from the lowest bidder, gets what he ordered, but precious little more. And it is such buying and such buyers who discourage progress. It is such buyers and such buying that tempt the babbitt manufacturer to cut his costs to the bone and then scrape the bone, regardless of the effect on the product's quality so long as it will pass muster.

What is the solution? Confidence! The babbitt buyer should select manufacturers in whom he has implicit confidence, particularly those who have achieved a reputation and good will of such value that it would be business suicide to lower the grade of their product.

John Glew*: Your request for developments in Electrical Maintenance Shop Practice, covers quite a large field, as there are no two men having just the same idea, and no two shops having the same conditions. The discussion when taken in detail, interests all who are interested in most any stage of electricity. However, we all have pet hobbies along certain lines, and I will not attempt to answer all the questions asked in your questionnaire, but be as brief as possible with certain questions which occur most in our practice here.

First question (C)—Advocating a running test on all equipment if at all possible. Of course on some equipment it would not be at all practical which should be taken into consideration, but for instance, small controllers; starting boxes; relays (most all types); armatures up to a certain size, and other equipment of this kind. With this, we are governed by results obtained. First, workmen are not immune from making some minor mistakes in rebuilding, and sometimes defective material. When a machine is down for some repair part and you take this particular part from the shop, you are most certain that it will work, of which a runing test assures you beforehand.

Second question (A)—Armatures arriving at shop with one or more damaged coils, it is usually best to rewind, especially in the smaller machines. Windings which have had service, usually the insulation becomes brittle and breaks very readily, especially so with armatures which have been impregnated and baked.

Second (E)—Bent shafts have been treated and straightened successfully by placing same in a turning lathe and applying heat to the part stressed, and by the use of a heavy bar and block for leverage. Of course this is the old fashioned way, but have had very good results here.

Second (E-234)—Worn journals, pinion pits and bad keyways are electric welded, in the case of bad keyways, same to be welded completely over and turned, and new key seat on opposite side of shaft. Great care must be exercised in the distribution of heat around the shaft for fear of warping. We have at this time successfully welded and refaced crane, truck and trolley wheels by this method. However, we could not say the results were as good as using new heat treated wheels.

(F No. 1)—I do think factory commutators prove sufficiently superior to justify the additional cost, and as well the complete commutator mounted on bushings ready for leads to be soldered in. Firms who specialize in the manufacture of such equipment, are able to handle and stock material for the manufacture of these articles when it would not pay the smaller maintenance repair shop to.

(F-4)—The only application we have in regard to undercutting, is for crane service only, having experimented considerably along that particular line in one particular plant. For instance, if using powdered coal for fuel and having any amount of this matter in the air which cannot always be avoided, if using open motors, trouble is experienced very shortly by armatures heating and ring fire on the commutator, as in an open coil. The results are that the machine is shut down and commutator cleaned out between bars, with the result that each time you cut the mica deeper in cleaning, and very shortly a refilling job is necessary. The result that undercutting has almost been abandoned except in crane service or enclosed motors in this plant with very good results. However, more care must be taken in regard to sanding and high mica. Of course, carbon brush consumption will increase considerably if this is not watched carefully.

(I No. 1)—As to electric shops equipping themselves to make their own coils, would be governed by the size of the plant and repair shop; also the investment on equipment and material to be carried in stock for this purpose. In this day and age, it is fine to say that we are independent so far as the outside world is concerned. We can make our own coils right here, no matter what class or type. One plant may be justified in doing this, while another may not. Of course, all this is taken from a financial standpoint, for that is the part which really counts when the whole thing is summed up. Perhaps we may have one particular kind of coil that is used quite often. This would be a good investment, providing we replaced this coil often enough. In regard to replacing any particular coil an unusual amount of times, the result is an investigation, immediately to find the cause, for there must be one somewhere. Taken from this view, I hardly think it a paying proposition.

In winding practice question "A", welding end rings to bars on old motors, in a great many cases has been successful here, leaving out the bar insulation. Of

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course care must be taken to properly balance the rotor. Have had a few cases of actually casting an end ring of solid brass to the rotor bars, having same turned and balanced, giving very good results. The motor itself would be subject to a higher temperature at a given load, for the reason of destroying air space and air current paths.

(A)—We advocate when possible, shop men to repair control, in preference to maintenance men. The latter class of mechanics are more of the class of "quick fix", and some of the finer features of the control might possibly be slighted and perhaps cause for more delay. Some type of control might be well placed under their hand. However, we might well be governed by the class of mechanics in either class of men, as it is the human elements that enter into these questions, and for the foreman or man in charge to decide, which refers us back to the first item of which no two mills have the same operating conditions.

B. A. Cornwell*: I have been very much interested in Mr. Cummins' paper, especially that phase of the paper referring to armature shaft repair practice, d.c. equipment, and commutators. There are four questions in this part of the paper to which my discussion will be confined, namely:

1—Should damaged commutators be repaired at mill shops, or is it more economical to return damaged commutators to the manufacturer for repairs?

2—What shop equipment is necessary for a good commutator job?

3—Do factory commutators prove sufficiently superior to justify the additional cost?

4—Do you advocate purchasing assembled bars or complete commutators mounted on bushings?

During the past 14 years I have been actively engaged in steel mill work and I know from experience the requirements of a commutator to be used on severe steel mill service where it usually has to operate without much attention in a dirty, greasy location. I have recently started to specialize in the design and construction of high grade commutators suitable for any class of service and am pleased to have this opportunity of giving my views on the four questions listed above, and will take up each one in the order given.

First—Should damaged commutators be repaired at mill shops, or is it more economical to return damaged commutator to the manufacturer for repairs?

A discussion of this question involves the consideration of two items; one is the extent of repairs necessary and the other is the emergency of the job.

Extent of Repairs. If only one or two mica segments are pitted between bars and the rest of the armature is O.K., this small job can be done in the mill shop at a low cost, and if carefully done the commutator should be as good as new. If a hole has been blown in the commutator, involving the replacing of some commutator bars, mica collars, or repairing the hub, then the job should be sent to a fully equipped commutator repair shop. I have found that it is almost impossible to make a good job if the bars used for replacing have to be filed to the shape of the other bars or if the mica cones have to be patched.

Emergency of the Job. If it is a breakdown job, the element of time must be considered. To send a job outside would require almost a week if everything went smoothly. Any well equipped repair shop should be able to do a commutator repair job in two or three days provided the copper segments are not damaged badly enough that new ones will have to be made up especially for the job. If the job is sent to the motor manufacturer the probabilities are it can not be put through the various departments and processes under a month or six weeks, except in a few cases the service station of the manufacturer might be able to make the repairs in a couple of weeks, using stock materials. The ordinary manufacturer is not anxious for this kind of repair work and consequently they charge more than you would pay an outside commutator repair shop which specializes in commutator work.

The only satisfactory way of repairing a commutator involving the replacing of all mica segments or part of the mica segments and some of the copper segments is to reassemble the commutator in an assembling jig and remachine the cone surfaces. If the commutator cones are not remachined it is impossible to ever get a commutator in which all bars will remain tight and give satisfactory service.

The ordinary mill electrical repair shop does not have suitable material for making mica segments; the mica in stock may not be of the proper thickness, then you have the delay of waiting on mica. Uusually the motor for which the commutator is to be repaired has been in service so long that it has become obsolete with the manufacturer and you will have to wait an excessively long time for the repairs. Also you will find that on the newer types of motors even stock delivery from the manufacturer means two to three weeks, while the up-to-date repair shop can furnish this commutator in three to four days.

By buying from a well equipped outside concern you can get exactly what you want, as more time can be given to making any changes that you may desire.

Second—What shop equipment is necessary for a good commutator job?

The floor space required for the necessary machinery for building good commutators is hard to obtain in a steel mill repair shop, and the necessary tools required are expensive.

In order to build up an assembled commutator using new mica V rings it is essential that the shop be provided with a press for pressing the commutator together; an oven for heating the commutator so that it may be tightened; suitable tools for tightening, and a suitable lathe in which to turn the commutator after it has been mounted on the core, or at least before it has been put into service. I might say that it would be impossible to make a commutator run perfectly true without turning after it had been through the tightening process.

In order to take rough bars and unfinished mica segments and build up a commutator complete in the steel mill shop would require an assembling jig in which to stack the copper bars and mica segments; a lathe equipped with suitable chucks for holding the assembling jig in order that the cone surfaces may be machined. All of the equipment mentioned above, together with a machine for slotting the commutator segments for the armature leads and another machine for tinning these commutator slots. It would be necessary to provide an assembling jig for every different size of commutator. For any great amount of

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commutator work the necessary lathes and milling machines, baking ovens, presses, assembling jigs, tools and chucks, would involve an outlay of approximately $5,000.

Third—Do factory commutators prove sufficiently superior to justify the additional cost?

This question involves a number of points. The first cost of a commutator is a very small item when compared to the expense and delay in removing an armature from a motor in steel mill service, installing the new armature, disconnecting the commutator from the armature and putting on the new armature and reconnecting the leads. A shutdown in the mill due to a poor commutator might easily cost the plant three to four thousand dollars. The difference in cost between a poor commutator and a good one is rarely more than four or five dollars; on larger sizes this difference may be a little greater.

Every commutator manufacturer uses materials which he believes suitable for the job, but the secret of making the best commutator is the method by which these materials are put together and the interest that the workman takes in the job. From the standpoint of the interest of the workman, which is a very vital factor, it would seem that a small repair shop would be able to turn out a better commutator than one turned out in a large factory such as the motor manufacturer.

A factory devoted to the exclusive repair and manufacture of commutators is forced to take an interest in the work as their very existence is dependent upon getting orders for commutators, and as you know it is only on repeat orders from satisfied customers that benefit can be made. The small commutator repair shop is forced to give service both from the standpoint of workmanship and delivery. The large manufacturer can exist if he never receives an order for a repair part to his motor, and having a multitude of interests he is not particularly interested in any one item. I therefore believe that a reliable small commutator repair shop can produce for severe steel mill service a better commutator than can the motor manufacturer, and at a lower cost.

Fourth—Do you advocate purchasing assembled bars or complete commutators mounted on bushings?

From my experience I would say by all means buy complete commutators mounted on bushings and not assembled bars and mica. Nearly any commutator repair shop can tell you the trouble they have with fitted assembled bars and mica. There are a great many reasons for this trouble, most of it being due to the segments not fitting properly, which in turn is due to either careless machine work or damage done to the commutator in shipping. Rather than buy assembled bars, a better way to do is to send the old commutator shell to be refilled. In having your commutators refilled you save about 10 per cent of the cost of the complete commutator. The old commutator having been duplicated on the original core, the core will fit the armature shaft and the slots for the wires will be right for the job. In sending away a commutator for refilling it is best to always attach an old bar to the cones. Even with the best of records the manufacturers are many times at a loss as to the size of slot for the armature leads; if the wrong size of slot is put in it makes trouble for the man who has to connect the commutator to the armature.

In conclusion, the following will give you a description of a good steel mill commutator which will stand up on severe service:

A good commutator should always be made with hard drawn copper commutator bars. The insulation between bars should be a high grade mica plate of uniform thickness and free from excess binder. The insulating V ring should be molded from mica plate. The hub or core should be in the majority of cases made from steel. The commutator bars and mica segments should be stacked in an assembling jig and tightened very tight. The cone surfaces should then be machined to fit the mica cones. After machining commutator for the cones the machined surfaces should then be carefully checked for drag-overs caused by the tool. Any drag-overs found should be removed. The machined surfaces should then be coated with a very thin coat of shellac free from wood alcohol. The mica cones should be free from dust or dirt which might have gotten in them while in stock, and if an old commutator core is being used it should be carefully checked to see that the shell has not been sprung out of shape. If out of shape it should be remachined to fit the mica cones. The mica cones should then be put into the commutator along with the core and tightened reasonably tight in a press. The commutator should then be baked to a temperature of not less than 350 deg. F. for several hours, the time of baking depending upon the size of the commutator. The commutator should then be taken from the oven and put in the press and tightened, and should then be put back into the oven and reheated to the original temperature and then allowed to cool off. After it is cool it should be retightened and it is then ready to be machined on the outside. The bars should be so tight that they cannot be moved with a hammer and chisel either endways or downward. Such a commutator will give good service and stand up under severe conditions of steel mill usage.

Arthur J. Whitcomb*: The cost of conducting an electric repair shop is an appreciable item in the total operating cost of an electric maintenance department. Only too often is the electric shop looked upon as a necessary evil and not treated as the money saving proposition which it really is. Consequently, I think that more attention should be given to this subject by our association. An interchange of ideas, such as Mr. Cummins had in mind when laying out this topical discussion, should prove of great value to our membership.

I will not discuss all of the points given in Mr. Cummins outline as I feel that there are others here who can give a much more valuable discussion of them than I. However, there are a few items concerning which I would like to say a few words.

In many plants that I have visited, no attempt is made to keep any record of repair cost and no analysis is made of the repair charges against the different motor installations. Equipment sent into the shop for repairs should be accompanied with a tag, stating from where the apparatus was taken and the reason for taking it out of service. A few notes of this kind save time in locating faults and in keeping track of the apparatus. On this same tag can be placed the shop order number covering the job and thus the exact cost can be charged against it. Although it requires a little more clerical expense to summarize and analyze these costs, the economies obtained from it are valuable. One plant that I know of has had such a system in effect for fifteen years. By

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means of the information obtained, the superintendent has been able to put through improvements which the management would never have stood for except for the convincing data he was able to show.

I advocate a running test of repaired equipment, such as motors, compensators, starters and the like. It is taking too big a chance not to make some tests on the equipment before it is placed in reserve against some future breakdowns. When you want the repaired equipment, you want it badly, and a second failure on top of a breakdown is a hard thing to explain to the head of the plant. Yet, the electric shop cannot be converted into a testing laboratory, taking saturation curves, load tests, heat runs and the like. One plant that I have visited has a system that seems to produce satisfactory results. Armatures are given the customary test for ground and shorted coils. All other equipment is checked for correct connections and given ground tests with a magneto, followed by the usual high voltage test. All motors are given a running test at no load. One corner of the shop is equipped with a compensator for starting squirrel-cage motors, a rheostatic drum controller for the wound rotor induction motors, a face plate starter for the d.c. motors and an arrangement of resistance to be put in series with the series field of the series wound mill type motors. By means of the latter, it is possible to operate the series-wound motors with the series field shunted across the line through this resistance and hence run the series motors at no load.

In this manner all equipment is made to run at no load before leaving the shop. Although this is not as satisfactory as giving load tests, still if the repaired apparatus runs at no load, it has a good chance of running at full load, and as I have said before, the electric repair shop cannot satisfactorily be made into a testing laboratory.

For building up worn pinion fits and bad keyways, I have found arc welding very satisfactory, especially when using metallic electrodes. I see no reason why the same method could not be used on worn journals although I have no experience to quote from.

The question, "Do high grade brushes bring any tangible returns in increased commutator life?" in a way, is hard to answer. Poor commutation naturally results in a decreased commutator life; good commutation the reverse. The selection of brushes should be governed solely by their commutating performance and not by how much they cost. From the results of tests on seven rotary converters at one plant I found that high grade expensive brushes were giving an average brush life of over two years, while cheap brushes lasted a little over six months. The expensive brushes required no commutator maintenance while the cheap brushes did. On the other hand, in many mill-type and general purpose motors I have found cheap brushes doing as well as expensive brushes. In my opinion, if the brush commutates properly, satisfactory results will be obtained, regardless of the price of the brush.

The question as to whether the electric shop should be equipped to make their own coils depends on the size and number of motors in the plant and the variety of type and make of motor used. A small shop in a small plant naturally would not want the coil-winding facilities of a larger plant and could save money by purchasing the majority of the coils. The medium size and larger plants, I believe, should be equipped for making most of their coils. Of course, coils for large main drive motors and generators should be purchased. One of the main reasons that I favor a coil-winding department is that it is much cheaper to keep a stock of wire for making coils than it is to keep a stock of purchased coils.

Repairs on control panels and resistor frames, I believe, should be done by the general mill maintenance men. Most of the repairs on panels are changing coils, arcing tips, arc shields, and other small parts and are of such a nature that they can be more easily done right on the job. Grid resistors are simple to repair and furnish good occupation for the idle time of the motor inspector. Compensators, face plate starters, drum controllers and the like, I believe, are best repaired in the shop. Many of the repairs require better workmanship than the motor inspector is likely to give. Then, too, when repairs are required on this class of apparatus, a complete unit is usually substituted for the defective one and the defective one is not repaired at its original location but is taken into the shop. Of course, simple repairs, such as replacing arcing tips, and so forth, should be cared for by the general mill maintenance man.

I have found several plants taking steps toward the standardizing of their resistor frames. One plant is now limiting control manufacturers to four sizes of resistor frames when buying new contorllers, that is, in equipping a new mill with controllers, all of the control would be bought from one manufacturer and he would be limited to four sizes of resistor frames in designing the control. Some of the other plants which I have visited were limiting manufacturers to five and six capacity of resistors. Still, another plant buys its controllers without resistors and then purchases all of its resistors from one manufacturer, thus standardizing on one make of resistor and at the same time limiting the number of sizes. This latter plan has the disadvantage, however, that it is not so easy to hold the manufacturer accountable for the performance of his apparatus if he does not supply the controller complete with resistors.

G. E. Stoltz*: The very nature of the service required of electrical apparatus in a steel plant would make it impractical to operate without a repair shop. While it may be questionable as to whether a steel plant repair shop should manufacture apparatus, there are times when quick repairs are necessary and it is essential that repairmen be at hand to take care of the work immediately.

It is possible that repair parts can be purchased from the original manufacturer to advantage, but this can only be determined by an accounting system kept by the electrical superintendent. The fact that repair parts may be manufactured in the steel plant repair shop at a first cost less than it would cost to purchase these parts outside, does not necessarily justify the electrical superintendent in making these parts. If coils or other repair parts purchased from the original manufacturer give longer life the electrical superintendent may save money by paying a higher original purchase price. We believe the safest method of settling this question would be to compare the cost of maintaining electrical apparatus per year.

We are often requested to make a comparison in the cost of the operation of a mill where both steam engine and electric motor are considered. If we simply assume a reasonable water rate on the engine which may be obtained under test conditions, electric drive will seldom show to advantage. However, if we select two plants rolling about the same product and approximately the same tonnage, one being steam driven and the other elec-

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tric, we always find the cost of producing material in the electric driven plants is considerably less than in the steam plant. The cost of producing steel in a plant is not only effected by the main drives, but also the cost of keeping all electrical apparatus in repair. If it is found that a plant which purchases repair parts direct from the original manufacturer has a lower annual maintenance charge than one which manufactures its own repair parts, this we believe would be the answer to the question brought up in Mr. Cummins' paper rather than a comparison of the original cost of a set of coils or other repair parts.

There is another factor which should enter into the cost of making repair parts on certain applications and that is the loss due to the interruption of production. If a blooming mill must be shut down while a screwdown motor is changed the cost of making this change or repair may be considerably more than the labor and material cost of the repair parts, since the cost of holding the mill idle should be added to the cost of the repair itself.

This question can hardly be settled by a general discussion, but I believe the electrical superintendent can arrive at the correct basis for handling his repair parts by keeping accurate cost records of repairs.

General Motor Repair Shop Practice

W. G. Colson*: (a) All equipment brought into the repair shop should be thoroughly cleaned before the same is actually placed in the shop. If this is impossible, a gasoline or naptha cleaning tank and blowing out station should be provided with hoods, so as to draw off fumes and dust, since the blowing of dust into clean and repaired equipment is very undesirable.

(b) Depending upon the size of the shop, the foreman, or in case of a large shop, the sub-foreman should make the inspection of equipment returned for repair. Great assistance can be given by the field men who remove defective equipment, and we favor a card tag system for reporting such matters by field men.

(c) We advocate a running test of repair equipment as a final test. Due to the wide variation in drives in the average foundry or mill a load test is usually quite difficult to make, although it would be desirable.

(d) The apprentice system of training shop personnel has proven very satisfactory.

Armature Repair Practice, D.C. Equipment

(a) At the discretion of the foreman, any larger armatures with one or more damaged coils may be repaired by replacing such damaged coils. Good judgment must be exercised, however, so that an armature with charred insulation on a majority of the coils and possibly only one or two coils broken and shorted, will not be repaired, as such a practice means double work, inasmuch as the armature, due to rough insulation, would soon break down again. We have no definite data on this subject but follow in general the above practice.

(b) Damaged commutators, if crushed for example, due to accidental dropping of the armature, had best be scrapped. We do not favor at all the rebuilding of a commutator by replacing only a portion of the bars. Our principal commutator repairs consist of re-turning. For this only a fairly good lathe is necessary.

(c) We favor spraying, either with an air drying or a packing compound, rather than dipping. We object to dipping due to the waste of insulation varnish, and due to the fact that it requires shielding of the parts of the armature such as bearings, commutators, etc., from which the varnish should be kept away.

(d) We have experienced very little trouble in breaking armature leads in wire wound coils. We favor in large coils the use of flexible leads to eliminate trouble from breakage of solid wire leads.

(e) In regard to shaft practice—

1—Bent shafts, unless on very small motors (5 hp. or less), should be discarded, inasmuch as a bend is usually accompanied by a minute fracture of the shaft which will sooner or later extend and cause breakage.

2—Worn journals may be cleaned up by returning, if wear is slight; otherwise we favor welding up with metallic arc and re-turning to original size.

3—Worn pinion fits: In order to keep pinions, whether straight or taper bore, standard, we always weld up with metallic arc and return to original size, when a pinion fit becomes worn.

4—Bad keyways are also best welded up and re-cut.

(f) Commutators:

1—Factory commutators are generally made of a better grade of copper and are more carefully made as to workmanship, and therefore justify the additional cost.

2—We favor the purchase of copper and mica segments assembled and bound but without being mounted on bushings, inasmuch as the bushings and V rings are not subjected to wear, and if carefully handled a wire bound commutator as delivered from the factory, with the use of new mica V rings and bushings, can be very satisfactorily mounted up on the old bushing.

3—We do not use any paint or cement other than shellac in insulating commutators.

4—We find undereutting to be impractical on motors which are repeatedly plugged, particularly crane hoist motors. It seems that undercutting permits an arcing across on our hoist motor armatures, for which reason they are not undercut in this service. In general, undercutting is undesirable where the motors are subjected to dust, particularly in a foundry where the same may be filled with metallic particles. An undercut commutator fills up with this material and forms a high resistance path for current across the bars, which results in overheating.

5—High grade brushes give better results in regard to life and good operating conditions of commutators. We are skeptical as to the economy of the use of higher priced material on crane motors in foundry service. We do, however, find high grade brushes almost indispensable in the operation of a 750 kw. rotary converter. The ordinary grade of brushes result in burning and roughening of this commutator, on the d.c. end, which operates at 500 volts.

(g) In regard to bearings—

1—Permissible radial wear in d.c. armatures from 1/32 to 1/16 of an inch.

2—The permissible wear for a d.c. rotor is 1/32 of an inch.

3—The most reliable way of checking bearings for radial wear is a pinch bar and a fiber feeler gauge.

4—Bearing shells should always be tinned before rebabbitting. However, if care is taken on melting out the old babbitt so that shell is not heated too hot, the old tinning can be retained in almost every case.

5—We are very careful in handling our armature babbitt that it does not get contaminated by the addition of cheaper grades of babbitt. We do not at present have

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pyrometer equipment, but are considering the addition of this to our babbitt melting equipment, as the overheating of babbitt is not only wasteful but results in a degraded metal for bearing service.

6—We are using waste packed babbitt bearings to a great extent and find our armatures comparatively free from oil.

(h) In regard to shop practice on anti-friction bearings—

1—These should be removed by being subjected to an even pull with a tool similar to a pinion puller.

2—Their ultimate life, if always properly lubricated and of a high grade of manufacture, is almost indefinite. Greasing should be handled with compression gun with flexible hose coupling.

3—Our motors equipped with anti-friction bearings are invariably free from grease and oil on the windings. Our application of anti-friction bearings consists, however, of the use of ball bearings on induction motors exclusively. We are contemplating future extension to include d.c. crane motors.

(i) Coils—

1—We do not advocate any plant shop making their own coils, except in a case of emergency. The work can be done far better and far more economically in a manufacturer's shop. We have in some instances secured very satisfactory coils wound by jobbing shops who make a specialty of coil production, and have also in this manner secured coils at a saving over the price quoted by the motor manufacturer.

(j) In regard to dipping and baking, we favor, rather than dipping, a spraying process, inasmuch as there is less mess to the process and also a conservation of varnish.

1—Coils should be kept free from grease during winding and when finished should be well blown out by compressed air, but not in a manner that would blow dust into other finished repaired motors.

2—The armatures should be well dried before spraying, either by allowing to stand in a warm place for a day or so, or being subjected to a high drying temperature in a drying room or oven.

3—As indicated above, we favor spraying rather than dipping. There are a number of reliable brands of varnish for motor winding insulation on the market.

4—With careful spraying with a small spray can, the removal of excess varnish is not encountered, inasmuch as only the coils themselves receive a coating of the spray.

5—Baking temperatures and times will vary with the kind of varnish used and with the depth to which the spray is allowed to saturate.

A.C. Stator Practice—Cores

(a) Restacking is necessary when the laminations become loose and chafe on one another through vibrations until each lamination becomes in clean metallic contact with the other. Such a motion also exposes some laminations as sharp edges away from the remainder and results in cutting wires of the winding in the slots. Restacking should never become necessary provided the bolts or rivets holding the laminations together are kept tight. When restacking is necessary, each lamination should be flattened out, the burrs removed from the slots and a thin coat of insulating varnish applied between each layer of the lamination.

(b) In preparing cores for winding, care should be taken that all sharp edges or burrs are removed and the comes thoroughly dried before the windings are applied.

(c) Riveted laminations are proving superior to older designs in that they do not loosen so readily.

Winding practice—

(a) Insulation of slots should be made by the use of any one of the several satisfactory slot insulations on the market. We favor an oil impregnated paper covered muslin fabric for this purpose.

(b) Coils should be well insulated when secured from the manufacturer.

(c) A. C. stators as well as d.c. equipment should be sprayed and dried or baked rather than dipped.

Rotors—

(a) We favor the brazing of the squirrel-cage end rings to bars to old motors which were originally fastened by riveting and where the riveting has become loose.

(b) Where bars were originally insulated the same should not be removed.

(c) We have comparatively few wound rotor motors in service, but in general handle these rotors in the same manner as d.c. armatures.

(d) We prefer to spray wound rotors rather than dip them.

Controllers

(a) Minor adjustments, such as of springs, sanding segments and finger tips, or lubrication of these with vaseline or adjustment of ratchet or springs, are best made by a general controller man who takes care of all of this equipment throughout the plant. Anything further than this, excepting possibly the renewal of segments, fingers or springs, should be considered as repair and made at such a time when the controller can be spared from service long enough to do the job in a proper manner. It may not always be necessary to remove the controller frame, since often the replacement of the cylinder, the finger post or flash board will be all that is necessary to repair the controller. When a controller becomes in poor condition it is best to remove it entirely, take it to the shop and practically rebuild it.

(b) When controllers are repaired in the shop we consider a ringing out test sufficient. We do not test them under full load current inasmuch as it would require considerable special wiring and test boards to do this.

(c) Resistance grids should by all means be standardized insofar as possible. We have come to the point where we are using for replacements and on new installations only four or five sizes of grids, although we still have a great many odd values of grids in service.

(d) Our control problems at this plant are somewhat unusual, in that we have 500 volt d.c. We use drum type controllers exclusively, and with the exception of railway controllers the manufacturers have never supplied any different controller for 500 volts service than they do for 250 volts.

In order to improve the controllers we have a number of special "stunts" in this regard. The finger post, for example, in the controllers which we use comes faced on one side with asbestos. We find it very desirable to continue this facing on the other two sides of the finger post, as it prevents arcing across and results in better service from the controllers. The cylinders proper, where built up of a number of contact blocks all keyed to the central shaft, are filled in between the asbestos composition blocks with a mixture of fire clay, asbestos and

shellac, which is applied in a plastic condition and enables us to make a smooth surface on the controller cylinder rather than a surface made up of many off-sets. This makes the cylinder easier to keep clean and results in less arcing across the face of the cylinder.

Final

(a) The shop can keep down its investment in supplies by a careful study of its requirements for the past three or six months. The electric shop should have the co-operation of the storekeeper, and an intelligent survey made at least every six months in this regard. The number of armature coils which must be kept on hand can be kept to a minimum if it is possible to interest some nearby jobbing shop which can be induced to make coils for the particular motors in service. We have one such party in our district who not only makes coils for us at a saving over the cost of those secured from the manufacturer, but also makes better delivery.

(b) The proportion of running armatures which should be kept on hand as spares varies decidedly with the type of service. It should never be less than ten per cent, and may in some cases amount to as high as fifty per cent.

A. J. Standing*: We will have to go into this shop discussion very briefly. Production of tonnage that will meet keen competition is the objective towards which our companies are aiming and production of tonnage on this basis implies continuity of operation, a reasonable operating condition we aim to realize without placing a prohibitive cost burden on the product. This is the problem of steel mill repair shops. Our maintenance cost is made up of several factors, two of which are labor and material. Material to a certain extent is beyond our control in price as a great deal of our material is purchased. Our labor is made up in part of an hour-rate which we must pay the men in competitive labor markets, that to a certain extent is also beyond our control while on the other hand some of it is made up of a percentage burden of overhead which we must carry. These repair hours reflect the cost of operating our shop, such as the overhead due to salaries of foremen, storekeepers and other men whose time cannot be directly charged to operating jobs, the expenditures for tools, lubricants, fuels, etc., all of which constitute an addition to the shop burden that goes out in the hour-rate, so that if we pay 50 cents an hour, we may have to distribute the time at 65 and 70 cents an hour. It is in the reduction of this differential we have to carry, that we can keep our costs down, both by conservative buying and especially the reduction of waste. We have found that the recovery of brass, copper, and waste materials of all kinds turned in and credited to our shop will produce a considerable saving and help to offset overhead and operating expenses in the shop. If waste were attempted to be collected by individual users, the individual credits received would amount to little or nothing, but by centralizing that waste and crediting the electric shop, the saving is reflected over the entire plant.

As regards some of the questions asked, I have some rather radical ideas. Our job is repair and maintenance and not the making of new equipment; that line of demarkation we stick to. When you start to build new equipment, new motors, controllers, commutators, and coils, it involves additional overhead, and it is a question if at all times that additional overhead is justified. You can't take maintenance men and add a new work on them which requires a lot of oversight, and expect your foremen who are loaded up with maintenance work to make new equipment to compete with outside manufacturers. For that reason we decided to go into repairs as far as possible, but to keep clear of manufacturing new material. This statement might be modified in the case of field coils and spares of that kind, which are really maintenance proper, but I refer to the expensive making of coils, building commutators, building up new motors and work of that kind. Taking up some of the questions as asked:

First (a) Cleaning of equipment in the shop. This applies principally to incoming or semi-finished repair work for the cleaning of which we are trying to get a little portico extended from the shop where it can be blown out and washed, as the dirt causes a great deal of damage to finished or semi-finished work if blown about the shop.

Second (c) Service obtained from dipping and baking needs no justification for the added amount of time put on an armature. Sometimes you haven't a sufficient number of spares ahead, or you can't afford to spend the time to give the necessary treatment, but in general it pays to dip and bake when you can by all means before putting armatures back into operation.

Second (e) Bent shaft problem. We have abandoned the proposition of straightening shafts, but for worn keyways and journals we depend on metallic arc welding. Carbon arc welding is used in the mills for recovering wabblers, shafts, and things of that kind and pays its own way many times over.

Second (g) Bearings are one of the most vital problems. Sleeve versus ball and roller bearings has been a big question, the fact remains that regardless of type, bearings must be calibrated and must be watched so the wear does not get away from the inspectors. The two general plant methods of doing this are, first by using a bar under the pinion and finding out how much play it has. The other way is by slipping a feeler around between the armature and pole pieces. We often find that a bearing is flooded with oil and it gets into the winding; if the overflow is blocked it is only a short time until the bearing is unable to take care of excess oil.

Babbitt. We have our own babbitt metal. We get a babbitt from our own foundries. We still use the old stick method, which apparently gives results as to proper temperature.

What proportion of armatures should be stored as spares? That depends to a certain extent on the size and nature of your work. Take as an example our two Bethlehem shape mills, when the loss of any one armature means shutting down and tying up 150 to 200 men. We can afford to carry more spare parts than if the apparatus being down would tie up a single unit. Our spare armatures are 21 per cent of the total installed motors. Part of these legitimate and part not legitimate where the rest of the motors having broken and scrapped.

Realizing that this subject is near to the hearts of all operating men here to-day I will close my discussion and hope to hear from many others.

W. T. Snyder*: It is likely that there are electrical department organizations that have not kept step with the development of their installations. Departments organized 15 or 20 years ago may still be going along

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*Superintendent, Electric Department, National Tube Company, McKeesport, Pa.

with the original form or organization, where, if a survey were made, it would be shown that reorganization to suit present-day conditions would be advisable.

Equipment has been added, forces augmented, responsibilities increased, men in responsible positions perhaps have not kept step with developments, facilities for handling equipment may be inadequate, men with greater skill may possibly mean a lesser number of men, and be more economical in the end.

The plan, years ago, where plants covered large territory, was to locate shops at different points in the mill. With the facilities available now, centralization is often preferable. There can be better supervision and better work with less men.

I agree with Mr. Standing that manufacturing of standard material, that can be purchased, is, generally, not advisable.

Geo. Richardson*: Our plant is a d.c. plant and since most all of our motors are of an obsolete type, we have to do practically all of our rewinding of armatures and field coils due to these motors being of the old type. Some weeks ago we had two armatures, one a spare to give out about the same time, that is one burnt out; then when we placed the spare armature in the motor it burnt out. This was a 150 hp. motor operating a straightening machine and had been in use about twenty years. We asked the manufacturer for a set of armature coils, but these coils being strap wound coils we received word from the manufacturer that it would take 18 weeks to get these coils due to the armature being special. (It was not special but obsolete with them.) Then we had to take the coils out of one of the armatures and scrape off all the old insulation and reinsulate the coils and then wind the armature again, at the same time we discovered that the shunt field coils were all burnt out. We also asked the manufacturer for prices on six shunt field coils and they gave us a price of $375.00. We then made a form and wound these field coils in our shop. When this motor was first purchased, the motor was wound for 220 volts but since starting our new power house we now operate at 250 volts which helps to burn out the shunt fields on our old type motors, therefore, when we wound these new field coils for this motor we added 120 more turns on each coil to compensate for the higher voltages. We completed these field coils in our shop for $149.77 including 50 per cent distribution and 17 cents per hour auxiliary labor. We had this motor shut down for one week.

We do quite a lot of our repairs on piece work; we wind armatures anywhere from one to 50-hp. on piece work, that is these armatures are mostly all round wire wound. This piece work has cut down the cost of armature repairs and we have found that it has been successful in our shop.

After winding an armature we test it by giving it a running test in a machine built for testing armatures from one to 50-hp., by brake test. While winding we use an a.c. tester and we also have a high potential test of 1,000 volts which we give the new wound armatures and the patched armatures from 220 to 500 volts according to the condition of the armature when we receive it in our shop.

Some years ago, before we started piece work and had about 400 motors in our plant, we had five armature winders and five helpers and the cost to rewind one CW old type 22 mill motor armature was approximately $40.00 to $45.00. Then I told the men that I would put them on piece work; the armature winder to strip the old coils off the armature and the insulation of the core, and to rewind the coils and reinsulate the core and place the coils in the armature slots and connect to commutator and if it passed the test we would pay him $22.00. After a short time and a few cuts in price we wound this same armature for $10.00 which showed a great saving. Now we pay for this same armature $6.92 for coils and $6.92 for placing coils in slots.

At the time we started piece work we had quite a number of ring wound armatures doing crane duty and we had considerable trouble due to the brass spiders breaking also getting loose and breaking wires at the commutator end, and, of course, we had considerable number of armatures to rewind, then we re-designed these armatures by slotting out the coil space in the cores and made a form coil to suit and cast iron spiders having end bells, then these armatures lasted very much better for this class of work that they have operated for years without rewinding. The speed of these motors was increased 150 rpm. but this did not cause us any trouble. These motors are in operation to-day and give us less trouble than any motors we have except the new M.C. mill motors. At the present time we have 1,200 motors and have only two armature winders who are on piece work almost all their time; we also have one or two other men who patch armature if it is required, we also have a commutator repair man who fixes up the commutators if it is required to be done; this man is not on piece work except when he is on some other kind of work. We make new commutators for all our old motors; this work is on piece work.

Our regular machine shop was working on the premium system until they saw the results we were getting, then they adopted the piece work system for some time.

You have to watch piece work to see that the men do their work O. K. If our winders make a mistake in connecting up the armature or if it is short circuited or grounded in winding which shows in the test, then he has to do it over again without pay which soon teaches him to be careful.

Our new mill type motors that we use to-day for series operation are so much superior to the old type that we have very little to do to them. Five years ago we installed ten 30 frame, 15 hp., mill type motors in our shipping yard on tables and drags and we have wound only three armatures of this size since installed. On our three 80 ton ladle cranes which have been in use now over two years using 60 frame, 40 hp. motors, we have not had the least trouble since installed; also we equipped blooming mill tables and 28 in. mill roll tables with four 80 M.C.A. motors in May 1919, these motors replacing four 50 hp. Richardson double armature motors, which had been in use since 1907 and these new mill motors have not given us the least bit of trouble since installed; also we installed two D.W. motors on transfer tables 28 in. mill in 1913 which has not given us any trouble since installed. We have recently installed new mill type motors on our four lifting tables in our 20 in. mill which are proving very satisfactory; if we have to wind any of these armatures we will purchase coils for them.

In doing piece work on winding one man winds the coil, bakes, tapes, stretches, tins the leads, completes the coil of a 25-hp. C. W. armature for $6.61, then the other winder insulates the core and places the coils in the slot and connects up to commutator with solder for $7.78.

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*Electrical Superintendent, American Bridge Company, Pencoyd, Pa.

On March 7, 1924:

Piece work	$14.39
Day work	2.45
Material	15.09
Auxiliary Labor	2.42
Discount 50 per cent	9.63
Total	$44.08

These armature winders averages $1.00 per hour on this work, armature completed in less than 1½ days.

F. O. Schnure: Practically all equipment requiring repairs is brought to the centrally located electrical repair shop of the Maryland Plant, Bethlehem Steel Company. Motors are cleaned with gasoline, carbon tetrachloride, or air depending on conditions, torn apart and the armature or stator sent to the winding department. Except in unusual conditions visual inspection is all that is necessary to determine the repairs required. After repairing, all equipment is tested on light load and armatures over 75 hp. are subjected to a full load test.

The work of our electrical repair shop is classified and carried on by the following sections or gangs: General mechanical, machine tool, bench, welding, motor repair, winding, controller repair and miscellaneous field coil and magnet repair work. We find the apprentice system of training employees satisfactory in training for winding and some other shop work, although the graduates of this system are rarely satisfied to take up mill work.

Armature Repair Practice.

A very large percentage of armatures arriving in the shop with damaged coils should be rewound. Where it is possible to save a portion of the coils these should be retaped and held until an armature can be rewound with a complete set of retaped coils. Armatures should either be rewound with all new or all retaped coils. Commutators should be repaired by the winder, otherwise too much equipment may be tied up at one time awaiting repairs. The dipping and baking process in treating armatures is just as important in preserving the life of insulation as paint is in the preservation of metals and wood used on buildings. In shaft practice the following is recommended: (a) Bent shafts—replace; (b) worn journals—turn down, welding is not really successful and economical in one out of 10 cases; (c) worn pinion fit—weld; (d) bad keyways—weld.

Except in special machines factory commutators do not justify the additional cost. As a rule assembled bars, bored out should be purchased. A cement-like compound applied to the front mica ring and in some cases to open riser commutators protects from deterioration by oil and grease. Undercutting is always practical and the performance of a brush on a particular machine is not determined by the cost of the brush.

Good bearing practice depends largely on the judgment of the man responsible for this work. Where changes in personnel are frequent, pyrometers may be useful as a guide to the novice and also serve as a means of education in an art only to be gained otherwise by the expensive cut and try method. Modern bearing designs have partly helped to eliminate oil from armature, and the antifriction bearing stands high but not entirely free from this defect.

Coils not requiring hot pressing can be made as satisfactorily in the steel repair shop as in any other shop. Although we can make the ordinary wire wound coil at from 60 to 75 per cent of the cost of a purchased coil we do not do this as a rule except in dull season when it is important to keep the winding force intact and available for the busy season. Hot pressed coils are usually furnished better in fit and construction by the motor manufacturer.

All armatures and stators are put through a 24-hr. drying, dipping and baking process. The armature to be treated is placed in the oven in the morning for drying, dipped in the afternoon and baked until the next morning in a well ventilated oven automatically kept at 240 deg. F. When desirable the second or third dip is applied.

We have not been successful in repairing old squirrel cage end rings by welding.

Control equipment in general should be repaired by shop men, the chief advantage being in the reduction of spare stock necessary. This practice keeps the mill maintenance force down to the minimum and allows more inspection while the work can be put on a contract basis in the shop.

Resistance should be standardized on the unit box, unit step basis. The different grid sizes should not exceed 10 for a plant with 2,500 motors.

The central shop and storeroom presents the best means in the reduction of supplies and coils. The stock of material can constantly be kept under supervision and down to the minimum. Five per cent of running armatures is a sufficient number to be stored as spares.

Since September, 1923, our armature winding and part of our control department have been on a piece work basis, and all things considered this practice has proven to be very satisfactory. We have been able to get more work through our shop and keep our men satisfied with apparently no deterioration in the quality of work turned out.

O. W. Bodler*: We have been trying to work up prices for repairing our motors on piece work. To do this we have been breaking up the work into elements and then drawing curves on these elements for the various size machines. So far, we have not been successful in getting all the curves.

The elements we have been working with are as follows:

A—Preparatory.
B—Stripping and cleaning.
C—Setting up loop winding and stretching machines.
D—Winding coils.
E—Tieing up ends of coils.
F—Stretching.
G—Sleeving coils.
H—Taping coils.
I—Cutting insulators.
J—Placing coils.
K—Connecting up.
L—Assemble for run test.
M—Painting or dipping.
N—Baking.
O—High voltage test.
P—Final inspection and O.K.
R—On d.c. machines, soldering leads in commutator.
S—Commutator repairs.

*Electrical Engineer, Eastman Kodak Co., Rochester, N. Y.

Time studies on these elements show that some of them decrease with the size of the motor increasing up to certain limits after which the prices increase in proportion to the size of the machine. Our problem is not solved yet, but we are slowly making headway.

One of our greatest helps has been the manufacturers giving us complete winding data of all motors purchased from them. This data consists of the number of coils, number of turns, size and kind of wire, amount of wire, type of connection, spacing of coils, etc. With this information we are able to determine whether we have all the material before the machine comes in the shop, and if not, can take means of getting it by the time the motor is ready for the material. I believe this information would be a good thing to get with all motors purchased.

If there are any here who have gone in on piece work on motor repairs, I would like to get any data they are willing to give.

J. A. Morgan*: We have a fairly modern shop, well equipped with machinery. Practically all kinds of repair work and some manufacturing of parts is readily accomplished. The most of our equipment is 220-volt d.c., with some 220-volt, 25-cycle a.c., and a limited amount of 6600-volt, 25-cycle a.c. other than transformers.

In the matter of armature repairs we do not believe in much patch work. Whether an armature is entirely rewound or not depends upon how many coils are damaged; that is, burned out, mechanically injured, oil soaked, etc. In general the tendency is to entirely rewind, as this makes the armature practically as good as new. Armature coils wire wound and up to 125 hp. are manufactured in our shop and we feel that it is the proper thing to do, especially as it tends to keep down our stocks of spare coils, gives us a more flexible stock of wire and quick service when necessary. Strap wound coils at present and the larger wire wound coils are purchased from the outside due to the limitation of our coil winding and pulling machines. Incidentally we reinsulate bars when repairing induction motor rotors. Likewise we braze the end rings of squirrel cage motors on the standard sizes. When it becomes necessary to repair some of our larger squirrel cage motors with special end rings we send them to the manufacturer as they have special equipment to handle the work.

All new coils manufactured in our shop and all old coils reinsulated, such as strap wound coils or repaired wire wound coils, are dipped and baked twice after the final taping. This class of work would be done better undoubtedly if we had a vacuum impregnating outfit.

In an emergency commutator bars are replaced or a commutator reinsulated throughout, but as a rule our commutator repair work is confined to mica "V" ring renewals, turning down in a lathe, grinding with a stone or undercutting. Ordinarily, badly damaged commutators are replaced as a whole by new ones. This we have found to be more satisfactory than to make extensive repairs thereon.

On large diameter slow speed commutators it does not seem beneficial to undercut and we have discontinued the practice. With the medium size and smaller commutators and high speed commutators we undercut. High grade brushes have brought us increased commutator life and better operation. Some time ago we ran tests on nearly all makes and kinds of brushes so that today we know the proper kind of brushes to use for a particular motor.

To date nothing really new or out of the ordinary has been adopted to prevent breaking of armature leads in wire wound armatures although we band out high speed armatures close to the commutator bars, which has helped materially.

Restraightening armature shafts is successfully accomplished on the smaller sizes operating at slow speeds.

We do considerable welding on shafts and would like to hear of the experiences other works have had in welding armature shafts where the taper pinion end is broken off at the journal. We have had a number of breaks of this kind and have gone into electric welding. On equipment used on ore handling machinery up to and including 125 hp., our experience shows that very few failures have occurred.

Shafts when worn at bearing fit are welded in some cases, especially when we have an expensive one or where it is difficult to remove a shaft or rewind the rotor or armature. Worn pinion fits and bad keyways are welded up and made serviceable.

When the babbitt is fairly thick, well dovetailed or keyed to the bearing shells, it is found unnecessary to first tin the shells before babbitting. On the other hand, when the babbitt will be thin we always tin the shell before pouring the bearing. In general a good lead base babbitt is used. It is found that babbitt pots with constant temperature regulator pays as it does not permit the metal to chill, maintains an even temperature and gives better results. Electrically heated, thermostatic controlled babbitt pots have been in use for some time with good results, especially since the control has been improved. It has been found advisable to shield or hood babbitt pots so that a draft of air, as from a window, will not hit the metal and tend to chill it.

We have not found any modern babbitt sleeve bearings which entirely eliminate oil from armature and motor housings.

Control equipment, except replacing of coils or arcing tips, which is done in the field by the inspectors, is repaired in the shop by experienced repairmen. This equipment when returned to the mills is practically as good as new.

The matter of a central general repair shop was mentioned by one of the speakers. This plan could not under present conditions be followed by us due to the service or speed required in making some of our repairs and replacements. I do not know where there is a plant in the Pittsburgh District at the present time that could take over all shop repair and replacement work unless it would be the Westinghouse Company, and then the assurance they could give as quick or better service 24 hours a day 365 days a year, than we could secure in our own shops. Incidentally the question of transportation of equipment between the mills and such a shop located outside would be quite a factor, likewise the passing of orders for such work through both organizations would be no small item.

We do not wind coils for high tension apparatus, like transformers, except in a minor way. If the working parts are damaged too much we send the equipment complete to the manufacturers for repairs and rebuilding. This is also true with our other 6600-volt machinery.

*Superintendent Electrical Department, Edgar Thomson Works, Carnegie Steel Company, Braddock, Pa.

Spot Welding

By G. A. HUGHES*

THE substitution of spot welding for riveting of steel plates, as originally proposed for ship building, has received considerable attention of late, and many interesting applications of welding processes have been developed. We will just briefly review the various forms of electric welding.

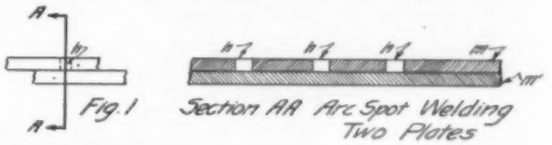
Electric welding processes may be grouped under three heads, Arc Welding, Spot Welding and Butt Welding, and combinations of these methods are in use. In arc welding the work is brought up to a welding heat by means of an electric arc (either alternate or direct current) drawn (a) between the work itself and a carbon electrode; (b) between two carbon electrodes which are held in the form of a V so the arc thus formed will heat the work; (c) between the work itself and a metal electrode. In the first and second cases a metal rod is used to fill in the weld. While in the third case the metal electrode itself is used to fill in the weld. By using the proper size of electrode and proper value of current both the work and the metal electrode are brought to the fusing point

FIG. A

and the electrode is deposited in the weld. It is evident that the metal so deposited is cast steel and that it has the properties of cast steel.

The weld may be porous, depending upon the chemical properties of the fill in rod, the amount of current and voltage used, the length of the arc, and number of interruptions while making the weld. Hence in the welding of sheet steel, plates, shafting, etc., a given cross section of weld cannot be as strong as a similar cross section of the parent metal.

To the average man "electric welding" means arc welding. It will be a surprise to many to learn that resistance welding is more generally used in the manu-



facture of the articles we use every day, than all other methods of welding combined. Its use extends from the welding of the stems on the watches in our pockets, the frames of our eye glasses, the handles on the knives and forks with which we eat (by this I do not imply that any one actually eats with his knife), the rims and frames of baby carriages and our automobiles, rims for truck wheels, and even rims for passenger locomotives. The term "resistance welding" as used in this article, applies to spot welding, seam welding, and butt welding, whether made by the Upset process. Flash process, or the new Contact Flash process. This latter process will be referred to again later.

In going into the history of spot welding, the records of the Patent Office show the first patent on spot welding was No. 1046066, issued December 3, 1912, to

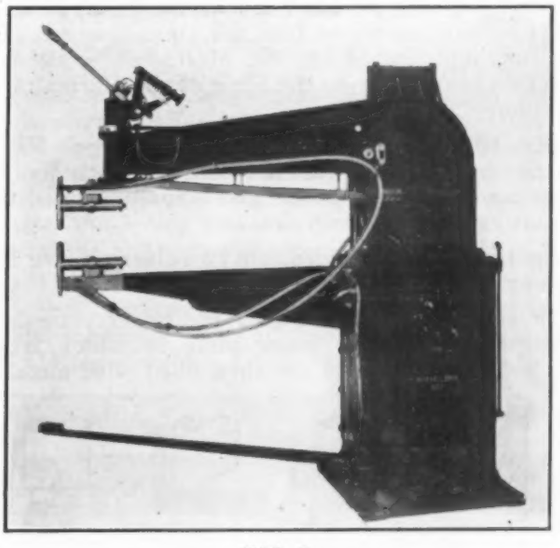


FIG. 2

Harmatta, covering the uniting of two sheets by passing a current through them and said weld surrounded by an unwelded section.

This has been contested in the courts and we will quote from the Canton Daily Repository in part in reference to the opinion of Judge John M. Killets, District Court of the U. S. for the Eastern District of Michigan, Southern Division, decided Tuesday, October 5, 1920†.

*Electrical Engineer, Truscon Steel Company, Youngstown, Ohio.

†Thompson Spot Welder Co., Plaintiff, vs. Ford Motor Co., Defendant.

" - - - in prosecuting its investigations, the committee also procured the services of patent attorney and electrical experts, and its investigations have been most thorough and searching, covering a period of three years. As a result of the committee's work it was developed that Mr. Fred P. McBerty of Warren, Ohio, as early as 1901 and nearly two years before the filing of the Harmatta Patent had constructed a welding machine, and successfully practiced thereon the

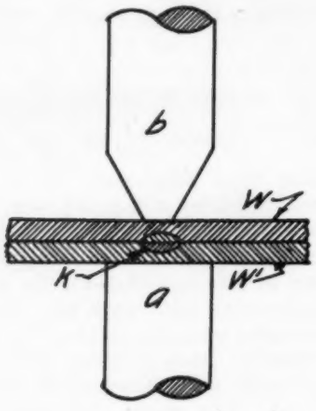


Fig. 3
Correct Type of Contact.

process of the electric spot welding at the plant of the Warren Electric Specialty Company, Warren, O., and the original machine was produced and used in court at the trial of the Ford case. In his decision Judge Killets has found that the Harmatta invention was fully anticipated by Mr. McBerty's work more than two years prior to the filing of the Harmatta application—"

Mr. McBerty was therefore the inventor. Fig. A is a picture of the original machine on which Mr. McBerty made his experiments and actually welded articles for commercial purposes.

Spot welding is divided into two classes: Arc Spot welding and resistance welding.

In arc spot welding Fig. 1 the upper plate M is punched and laid on lower plate M which is not punched. The holes H are then filled with metal by

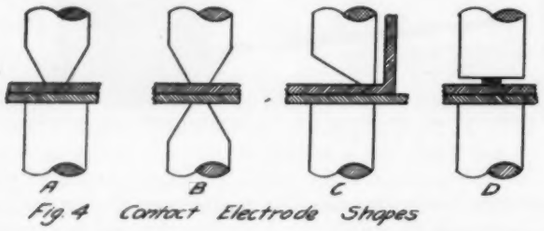


Fig. 4 Contact Electrode Shapes

an arc welder by one of the methods described above, the spots acting as rivets. It has some advantages over riveting where a limited amount of this class of work is required since the equipment for welding is much cheaper than the air equipment for driving rivets, also only one plate need be prepared. This method is still in the experimental stage and reliable data on tests is limited as to the cost and strength per weld on various size plates.

The principle of spot welding by the resistance method (and likewise in butt welding) consists in passing an a.c. of high amperage and low voltage through metals at point of contact, and when the metal is in a molten state, pressure is applied to force the metal together. Fig. 2 shows a typical hand operated spot welder. The theory is that in a series circuit, heat is produced in proportion to the resistance of any particular portion of the circuit. Now if the conductors leading from the source of supply of current be of low resistance and a piece of metal be inserted, the heat produced will be at point of contact. This is an ideal condition for spot welding.

In Fig. 3 the resistance between copper contact electrode (b) and work (w) and electrode (a) and work (w^1) is less than that between work (w) and (W'). As a result of this the greatest heat is produced at point K just where it is needed. When the metal in contact with the electrode (b) is in a plastic state (just before fusing) added pressure on (b) forces the molten metals together and makes a weld at K.

The different types of contact electrodes used in spot welding are shown in Fig. 4. (A, B, C, and D).

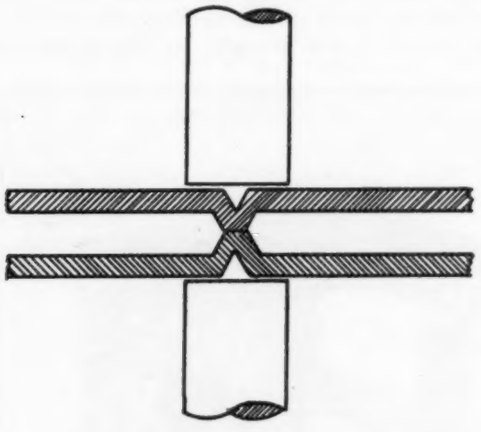


Fig. 5 Projection Welding.

To determine the proper electrode to use in welding material from No. 20 gauge to No. 12 gauge a test was made by taking two machines doing the same class of work, one machine being fitted with contact electrodes as shown in Fig. 4A. The other machine was equipped with contact electrodes as shown in 4B. At the end of one month's run the saving in contact electrodes on the machine using the electrodes shown in Fig. 4A was over 50 per cent while production was speeded up over three per cent owing to the time saved in dressing points of the electrodes. The welds made were satisfactory.

Fig. 4C shows the use of a contact electrode for close work as in corners. Fig. 3D illustrates the "button method of spot welding. A "slug" or "button" is placed between the contact electrodes and the work. When the work is at a welding heat the slug is forced into the work.

In Fig. 5, "projection welding" is illustrated. This method of welding has proved satisfactory on small work where the projections can be made at the same time material is formed or stamped, one die performing both operations. This method has been used

successfully in the making of brush holders for motors and generators.

A method of riveting plates together by means of a spot welding machine is shown in Fig. 6A, and the finished rivet in Fig. 6B.

This method is successful on rivets up to ⅜ in. using copper electrodes. Larger rivets require a special steel die for upsetting as the copper is too soft. This method of riveting is ideal since the rivet is hottest when completely upset and in cooling makes a tighter joint. The method is also preferred in some instances since it is noiseless and the welder is less expensive than forge and necessary air equipment to operate the air guns. In some instances it has proven economical by speeding up production over the air guns in driving rivets.

The question now arises—where should spot welding be used—and what thickness of plates are practical to weld? To decide whether it is better to rivet or spot weld an article one must take into consideration the use of the article. Sufficient welds can be inserted to obtain maximum strength of the metal welded. It is preferable for all work in which a smooth surface is desired, or where the stock will not permit the punching or countersinking of a rivet hole, in fact one is safe to say that spot welding can replace 90 per cent of the light work now being done. Special welding machines

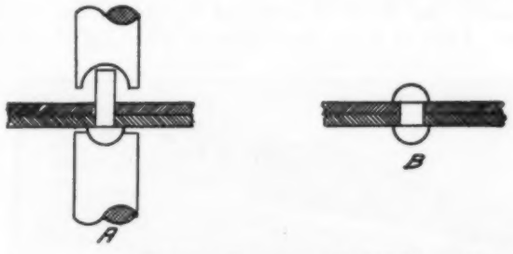


Fig. 6 Riveting by Welding Devices

can be built to take care of difficult shapes, and the saving in time and labor for maintenance of jigs, dies, punches, etc., have been as much as 75 per cent in some cases.

Fig. 7A shows two pieces of steel 3 in. wide and ½ in. thick that were spot welded on a 30 kw. hand operated machine. A tension test of this sample (all tension tests were pulled at ½ in. speed per min.) was 35,100 pounds. Total area of weld sheared was .65 sq. in. Sufficient pressure to force material together after heating could not be obtained on this small machine. Fig. 7B shows two pieces of 12 gauge. The spot pulled out of one sheet.

Fig. 8A shows two pieces of ½ in. material cut through weld showing union of metal. Fig. 8B shows the other half of A torn apart by driving a chisel between the ends. Note how ends are sprung in tearing the weld apart.

Fig. 9A shows a piece of 14 gauge sheet welded to a piece of ¼ in. plate. Note weld pulled out of plate when the two pieces were pried apart with a chisel, the 14 gauge being bent back to show weld.

Fig. 9B shows 14 gauge welded to a piece of ½ in. material. A chisel was driven on each side of weld and the 14 gauge sheet driven back. This sample was cut through center of weld to show union of metal. Fig. 9C shows two pieces of 14 gauge welded. Fig. 9 shows conclusively that both pieces do not have to be of the same thickness to insure a perfect weld. A 30 gauge sheet can be welded to a 1 in. piece of steel.

Fig. 10A shows a double lap joint with four welds made with 5/6 in. contact electrode. Plates are 3 in. wide of 5/32 material. This plate failed at 25,500 pounds. The shearing strength of the four spots was

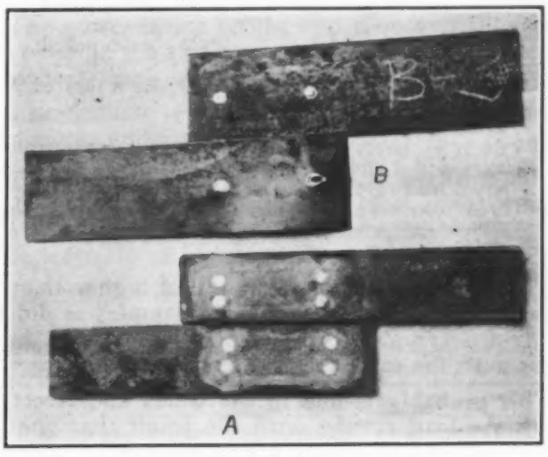


FIG. 7

greater than 6,500 pounds each in 5/32 in. material using a contact of 5/16 in. in diameter.

Fig. 10B shows single lap joints, 4 welds, 3/16 contact electrode. This plate failed at 25,050 pounds.

Fig. 11A shows two pieces of steel 2 in. x ⅜ in. thick welded with four spots. Total area of welded section obtained with a planimeter was .476 sq. in. The welds broke at 44650 pounds tension. A piece of this same steel showed an ultimate tensile strength of 66800 pounds per sq. in. This would show the shearing strength of the weld to be stronger than the tensile strength of the material. Upon careful examination the welds showed that they were under both a tensile and shearing force.

Fig. 11B shows two pieces of ¼ in. steel with four spots. Area of welds is .54 sq. in. A tension test was made and the welds broke at 45800 pounds or an average of 11450 per weld.

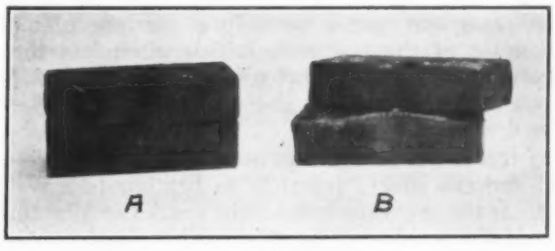


FIG. 8

Table I shows a comparison of the shearing stresses of spot weld and rivet joints in 14 gauge sheets tested in single shear.

Table No. I gives a comparison of the strength of spot welding against ¼ in. rivets for 14 gauge sheets. The test pieces were three inches wide. The single spot was put in center of sheet 1½ in. from edges. The tests with two spots were placed at inch centers

and 1 in. from edges. The three spot samples were in the form of an equilateral triangle 1 in. on centers and 1 in. from edge.

TABLE I.

Test No.	Size of spot.	Maximum load lbs.	Nature of failure.	No. of spots.
1	5/16 in.	4460	weld pulled out.	1
2	5/16 in.	7250	welds pulled out	2
3	5/16 in.	10920	welds pulled out.	3
4	One ¼ in. rivet was used, hole drilled and rivet inserted with care.	2920	Rivet sheared	
5	Two ¼ in. rivets were used, holes drilled and rivets inserted with care.	4700	Rivets sheared	
6	Three rivets were used, holes drilled and rivets inserted with care.	8390	Rivets sheared	

The sample with one spot tested higher than the average of the two and three spot samples as did also the riveted samples. The rivets were located in the sheets with the same relation as the welds.

This probably is due to the welds and rivets not taking the load evenly, with the result that one was partly ruptured before the others were fully loaded.

During welding it was noticed that some pieces heated much more rapidly than others and a careful

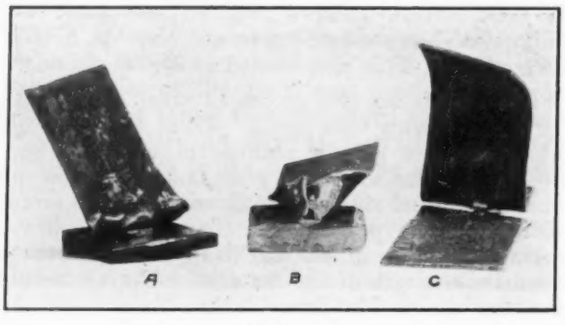


FIG. 9

study was made to determine why this condition was so pronounced. The heat generated depends upon the amount of current flowing and the resistance of the circuit. This resistance will vary with the pressure. Rust, scale, etc., cause burning of the sheet at point of contact of the electrode which often has the appearance of a welding heat while still not hot at point of contact between the sheets, resulting in poor or burned welds.

If too much pressure is used the resistance is lowered and the sheets are slow in heating to a welding heat. If the pressure is too light sparks will be thrown off and the welds will be poor. This can be remedied by increasing the pressure or lowering the current value.

When rust or scale is present on heavy sheets and pressure used is correct, a good weld can be made by first switching the current on for an instant. This will burn the scale or rust off and seat the contacts firmly on sheet. The current is then switched on and work brought up to a welding heat.

The pressure required varies with the thickness of the work, chemical properties of material and amount of current used.

Owing to its low resistance high carbon steel requires a very light pressure and heavy current to heat. In some instances the steel will not heat if a great amount of pressure is used.

Table II shows two grades of steel; low carbon and Vasco non-shrinkable.

Tests in Table II were taken on Federal Machine & Welder Company's 444B 30 in. throat, 35 kw. capacity. This machine is shown in Fig. 2. The instruments were inserted in the primary circuit of the welding transformer. The power factor is low. This is caused by the inductive reaction set up in the low voltage conductors. In making the weld in the Vasco non-shrinkable steel approximately 9,000 amperes was flowing in the secondary circuit. The conductors carrying this heavy current parallel the iron of the machine thus increasing the inductive reactance.

As the current is passed through the sheet being welded, a choking effect is produced depending upon the distance the sheet is inserted in the throat of the machine. This is most noticable in welding the seam

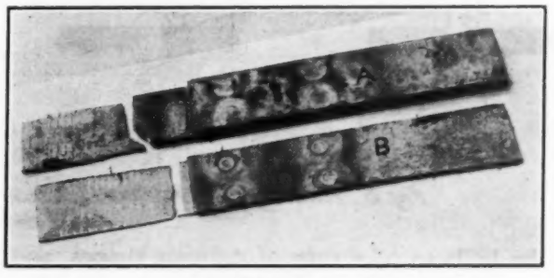


FIG. 10

of a cylinder. The time to make a weld will increase as the sheet is inserted in the throat.

This power factor can be improved if both conductors of the welder are short or placed on the same side of the work. By so doing the steel being welded is outside of the magnetic loop and the inductive effect is lessened. Fig. 12 shows a welder of this type.

Table No. III shows a test illustrating the above statements. The machines used are shown in Fig. 2 and Fig. 12.

This machine is built with a cast iron frame with a 60 inch depth of throat. It is capable of welding two 24 gauge to two 8 gauge sheet stock. Twelve welds per minute are made on the heaviest stock, two pieces of 8 gauge, of strength to permit the prying

TABLE II.

Volts	Amperes	K.W.	P.F.	Material used.	Time in sec.	Lbs. pressure to heat.	Size of spot.
220	244	24	.54	Two 3/16 in. mild steel plates.	15	50	⅜ in.
220	260	20	.35	Two 3/16 in. Vasco non-shrinkable.	20	100	⅜ in.

apart of the pieces and pulling out of the welded spots rather than breaking the weld.

It is built with a 40 kva. welding transformer in the upper and lower rotating heads—H. The primaries are in parallel while the secondaries are in series so that two spots must be made at a time. The four welding points D, two upper and two lower, are so arranged that they can be adjusted with a distance from three to eight inches between centers and are drawn apart a distance of five inches. The head can be rotated through an angle of 90 deg. by handle B to permit welding different angle on the stock.

The welding points are 1½ in. in diameter and held in water cooled holders. The cooling conductors also pass through the welding transformers.

Air is applied to the four cylinders C each operating an independent point. (This is to insure even contact over uneven or irregular surface.) The air control valve A is hand operated and so arranged

sumed was nearly doubled and the power factor greatly improved.

The current in the weld was 50 per cent greater on the two spot welder, and about 12½ per cent greater time was required to make a weld. However on the two spot welder, two spots were made at a time which will permit about 78 per cent greater production.

The electrical characteristics are better and welds are satisfactory.

The power factor on the two spot welder averaged .58, while on the single spot welder the average power factor was .46.

The ultimate tensile strength of a piece of the plate of 14 gauge under test showed 56500 pounds per sq. in.

The ultimate shearing load per weld (2 spots) averaged 8,942 pounds, average area of weld .1104 sq. in. This would give an ultimate shearing strength for one sq. in. of weld of about 40,500 pounds. This gives a

TABLE III.

Comparison of welds made with Single Spot Manually Operated Machine and Automatic Air-Operated Two Spot Machine. Material—Two 14 ga. plates and one 3/16" plate arranged thus— ═══ ═══ ═══ Two spots in each specimen.

	Automatic Two Spot Machine							Single Spot Machine						
	A_1	A_2	A_3	A_4	A_5	A_6	Ave.	B_1	B_2	B_3	B_4	B_5	B_6	Ave.
1. Voltage	208	206	202	204	208	202	205	212	212	211	211	210	212	211.3
2. Current	296	344	352	360	344	352	341	240	245	242	240	240	240	241.1
3. Top of Auto. Transformer	7	8	8	8	8	8	...	8	8	8	8	8	8	....
4. Kilowatts consumed	36.8	41.6	41.2	41.6	42.0	41.2	40.73	24.5	24.5	23.5	24.0	23.5	23.5	23.91
5. Power factor	60	59	58	57	59	58	58.5	48	47	46	47	47	46	46.83
6. Condition of sheets							Fair							Fair
7. Condition of electrodes							Good							Good
8. Size of contacts	7/16"	7/16"	7/16"	7/16"	7/16"	7/16"	7/16"	7/16"	7/16"	7/16"	7/16"	7/16"	7/16"	7/16"
9. Press. at electrode cont.	205 pds. to heat — 1060 lbs. compress — 700 pds.													
10. Time of weld (sec.)	*12.0	5.4	6.6	9.0	8.4	8.4	8.3	†7.8	6.15	6.3	6.3	6.2	4.5	6.21
11. Area of weld	.0494	.0421	.0648	.0810	.0629	.0680	.0614	.1035	.0910	.0870	.0852	.0856	.0840	.0870
12. Condition of weld			Good								Good			
13. Nature of failure	Weld	Weld	Weld	Weld	Weld	Weld	.....	Weld	Weld	Weld	Weld	Weld	Weld	.....
14. Load at failure	15670	13190	19700	17700	18950	16790	17000	10970	18310	18165	18520	18060	19760	17297
15. Load per spot at failure	7835	6595	9850	8850	9475	8395	8500	10970	9155	9083	9265	9030	8800	9383
16. Current in weld	12500	12500	12800	13200	12500	12800	12710	8000	8200	8100	8000	8000	8000	8050

*Two welds. †One weld.

that with 80 pounds on the line a pressure can be applied for the heating period of from 300 to 700 pounds between the points D depending upon the thickness of the stock. The second step on the air control valve applies full air pressure or 1200 pounds between the points D for the final squeeze. The air is then exhausted to withdraw the points.

The remote control switch is operated from the air control handle A mounted along with the regulating transformer in a separate case E. This regulating transformer supplies power to the welding transformers in eight equal steps from 65 per cent to full line voltage.

Table III also shows a test illustrating the power factor conditions as mentioned above. The machines used are shown in Fig. 2 and Fig. 12.

On both machines during test the regulating transformer was on tap 8 which puts the welding transformer across the line.

The voltage drop on the automatic two spot machine was a little greater than on the single spot machine, current consumed was greater, kilowats con-

ratio of average ultimate shearing of weld to average ultimate tensile-strength of 13 to 16. Under ideal conditions the ultimate shearing approaches the ultimate tensile-strength.

An integrating watt hour meter was installed on a welder to determine the current consumption for a day's run. Table No. IV shows given results obtained.

TABLE IV.

1480 Welds of two pieces No. 18 gauge sheet steel.
1050 Welds of four pieces No. 16 gauge and 1 piece 3/16 in. plate.

2530 Welds in 10 hours. Energy consumed 42 kwh.

680 Welds two pieces No. 18 gauge sheet steel.
1350 Welds four pieces No. 16 gauge and one 3/16 in. plate.
545 Welds one piece No. 18 gauge and one piece ⅛ in. mild steel.

2575 Welds in 10 hours, energy consumed 35 kwh.

The number of welds made in a 10-hour period was not large owing to the nature of the material. It requiring three men to handle the work and one to operate the welder.

A piece of plate was cut and spot welded together and sent to the chemical laboratory for analysis.

The following report was received:

1. From center of weld. Sul., .038; Phos., .020; Mang., .59; carbon, .08.

2. From edge of unwelded section but affected by heat: Sul., .042; Phos., .019; Mang., .60; carbon, .08.

3. From plate uneffected by heat: Sul., .040; Phos., .021; Mang., .58; carbon, .08.

The accuracy of integrating watthour meters recording the power consumed by welders have been questioned by many engineers, giving for their reason that, for the short period involved, the integrating wattmeter is sluggish and will not respond quickly enough. On the other hand other engineers claim that the deceleration of the meter disc will compensate for the slow acceleration.

No instruments were at hand whereby any data could be obtained on the accuracy of integrating watt hour meters for welders.

On account of the low power factor of a spot welder it is difficult to select transformers with proper capacity to care for the welding equipment for all conditions of welding load. The manufacturers of welders give their machines a very liberal rating and where one welder is used it is safe to install transformers of an equal kva. rating as the kva. rating of welder.

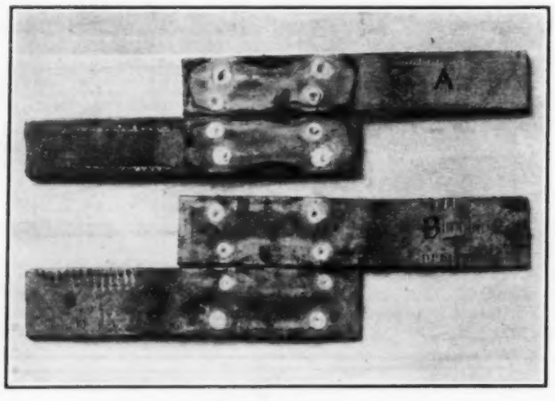


FIG. 11

Where more than one machine is used it is not necessary to install transformers whose kva. rating is equal to the total kva. rating of the welders. The load will vary from a fraction of a second to a few seconds depending upon the nature of the work, giving a diversity factor between total maximum load of the group of welders and the total rated capacity of the welders.

To determine this factor a series of tests was run on six circuits carrying only a welder load. The total kva. of three welders on a circuit working on light stock but large and difficult to handle was 90 kva. while the average high kva. consumed was 41, giving a factor of 45.5 per cent. Another circuit carrying two welders, one being semi-automatic with a total rated kva. of 110, working on heavy stock but easily handled showed an average high load of 73 kva. or giving a factor of 66.3 per cent.

Another circuit having six welders with a total of 190 kva. all of which were working on light stock and easily handled showed an average high load of 107 kva. showing a factor of 56.4.

These tests show that where several welders are installed the transformer kva. capacity should be about 66 per cent of the total rated kva. of the welders.

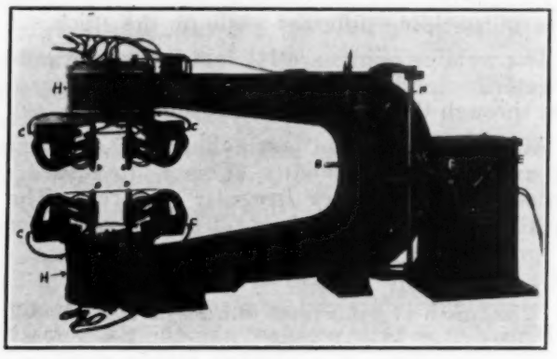


FIG. 12

All the machines referred to so far are manual operated or semi-automatic, and much depends upon the judgment of the operator. This factor "human element" is a serious one owing to the condition of labor today. An automatic welder, one which will make uniform welds and eliminate the human element is being sought out by manufacturers of today. Owing to the many varying factors some said such a machine could not be made. The Federal Machine and Welder Company has recently developed a machine which is shown in Figs. 13 and 14. This machine is designed to weld two pressed steel channels to form an I beam as shown in insert, Fig. 13. The machine

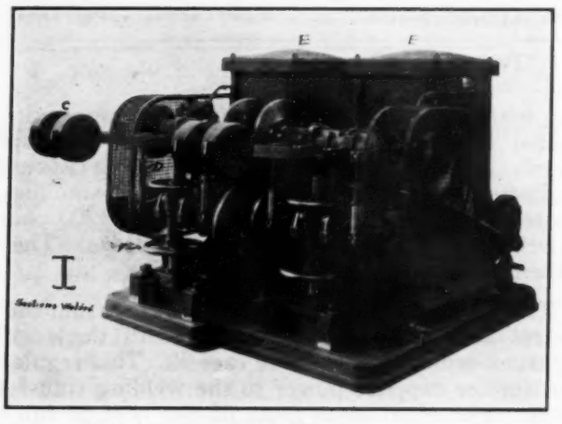


FIG. 13

is capable of welding two spots at a time in two pieces of ¼ in. material at the rate of 60 welds per minute. The welding current is controlled by an auto transformer in the primary circuit.

This machine is made in two separate and distinct units, each making a weld and independent of each other, but mounted on a common base. The welding transformers are located in housing E. The second-

aries of the welding transformer are connected to bronze bearings B and B'. In this bearing runs a bronze shaft with the welding disk electrode.

The electrodes A and A', also serve as rolls to feed stock through the machine. Thus the bearing and shaft carry current to electrodes A and A' completing the welding circuit. All parts carrying welding current are water cooled.

The screws F are for raising and lowering electrodes A—A'. Screws D (four in number) are to regulate the distance between A—A' so the electrodes will not short circuit. Suitable pressure is obtained for different thickness of stock by moving weights C (four in number) along the arms. Pressure can be varied from 900 pounds to 2000 pounds.

The theory of the welding on this machine is, that there exists line contact between the disc electrodes A—A', and the work; this offers great resistance to the flow of current generating heat. As the metal becomes plastic the disc sinks into the work slightly and as current is still flowing changes the line contact to a spot. The welds are uniform and satisfactory. The power factor is around 75 per cent.

The welding disc can be adjusted to weld beams from 4 in. to 16 in. Welds can be made from 4 in. to

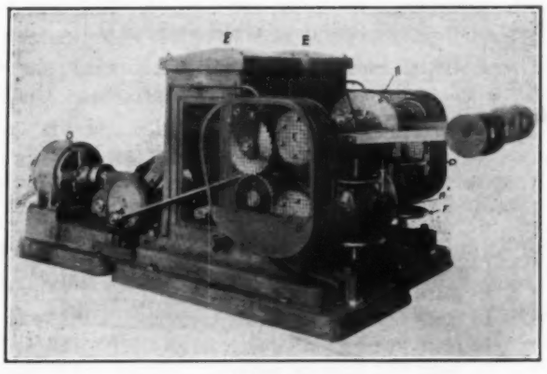


FIG. 14

12 in. centers. A variable speed motor is used to control speed of material through machine from 20 in. to 60 ft. per minute.

Following is a brief summary of the status of spot welding:

1. Spot welded joints can be made as strong as riveted joints and in many cases stronger.

2. Resistance welding machines can be successfully used in heating and driving rivets.

3. But little data is available on Arc Spot Welding.

4. Where several welders are used the source of supply should be about 66 per cent of total rated kva. of welders.

5. The thickness of material to be successfully welded will depend upon the size and shape.

Briefly taking up "Seam Welding", much development work has been carried on within the last two years. Until recently, two sheets of No. 20 gauge stock was the maximum limit for flat commercial work, while two sheets of No. 16 gauge stock could be seamed by previously scarfing the edges. The limit in length of seam for this work was about two feet. Now, however, two ⅛ in. sheets have been welded, and the length of seam can be practically anything that can be procured in commercial stock.

The seams can be made at a rate of 40 feet per minute on two 1/16 in. sheets, and 20 feet per minute on two ⅛ in. sheets, without any scarfing, or special preparation of stock.

In the classification, "Butt Welding", may be subdivided three classes; namely, (1) Upset Welding, (2) Flash Welding and (3) Contact Flash Welding, or Automatic Butt Welding.

As regards the first subdivision, it is interesting to note that it is the oldest, or first process of electric welding to be used. Its inventor is Professor Elihu Thomson. It seems that the Upset Welding process is being superseded for most purposes by the second classification, namely, Flash Welding. The first is made by butting the cold ends of the stock to be welded, and then applying the electric pressure. The second is made by applying the electric pressure before the ends are in actual contact, and utilizing the flash or minute arcs that play between the ends of the stock. This arcing or flashing quickly heats up the adjacent ends to welding temperature, at which time the current is cut off and the ends quickly forced together to complete the weld.

Some advantages of flash, over upset welding, are less power required, less upsetting or extrusion of stock, burned metal is thrown off in the flash, along with certain gasses, greater production (some rim manufacturers in Detroit are flash welding 300 automobile rims per hour constantly) and generally a stronger weld.

Some recent applications of flash welding are welding auto truck wheels rolled up from I beams with a cross section 10 in. wide by ⅝ in. thick, train coupler links for England's railroads, drop forged hubs for disc wheels for Cadillac, Studebaker and Dodge cars, flyers for looms, steel welded wheels for Ford cars, duralumin for a multiplicity of uses, and many others too numerous to mention.

The third subdivision, "Contact Flash Welding", is a new invention, soon to be placed on the market. It is in some respects very similar to percussion, but is radically different in others.

The weld is made almost instantly. The nearby metal is not heated and a weld can be handled immediately after being removed from the welder without burning the hands. The percussion weld was originally made by power derived from the discharge of a condenser, and is now made by adding the kick from a direct current coil, thus limiting the ability to obtain power in large quantities. The contact flash weld is made by power from a transformer, thus making it possible to obtain power in any quantity. The percussion process will weld successfully, stock ½ in. diameter. The contact flash process welds stock 1 in. diameter at present on an experimental welder, and it is expected to weld 1½ in. diameter stock or larger when a final model is built.

By some one of the resistance welding processes, nearly all metals and alloys can now be welded; tin is the notable exception. It can be welded, but the

weld deteriorates so rapidly that it will fall apart the next day, due to what is called "skin disease". Lead, which was formerly very difficult to weld, can now be readily welded by the contact flash process. Stellite, which has been the cause of many disappointments and discouragements in the past, is now being successfully welded and is superseding high speed steel at much lower cost. Brass is in a class by itself since the ease with which it can be welded varies with the copper and lead content of the particular sample being welded. Duralumin, if welded by the gas welding process, requires best treating or annealing after welding to prevent deterioration in the presence of moisture, but when electrically welded, requires no annealling or treatment, and the weld is as strong as the original metal. Some grades of steel require annealing after welding to maintain normal strength. The cross section of stock that it is possible to weld by the resistance process now seems to be limited only by the electric power available. Already, wires as small as electric light bulb filaments can be welded as a

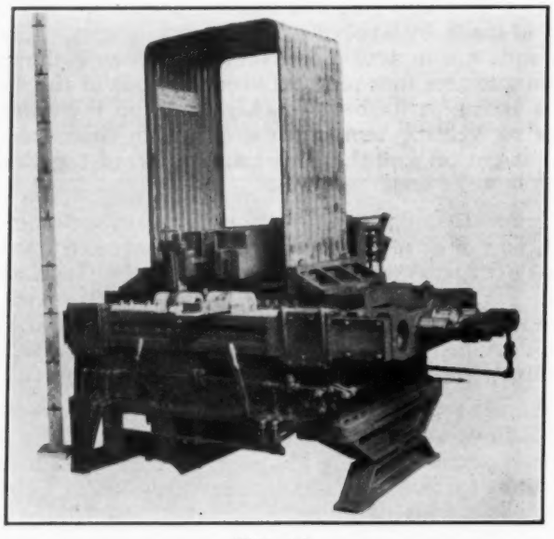


FIG. 15

minimum, and from 16 to 20 square inches as a maximum. However, welders could be built to weld practically any large cross section.

A special adaption of the electric welder is seen in the electric pipe heater, which can also be used for heating rods or bars or billets; also the electric rivet heater, which will heat rivets of practically any size for practically all purposes. The only difference between the welding process and the pipe heating and rivet heating process is that the pipes, bars, billets or rivets are in one continuous piece instead of two, and are heated by the actual flow of current through them. The rivet heaters are quick, clean and reliable pieces of apparatus. One great advantage of an electric rivet heater is that it can be used inside of a Pullman car or state room, or other nicely finished or painted compartments, without smoke, grime, soot or cinders.

The following test was made on a butt welder welding a bar of iron with one square inch area and obtained the following results in average power consumed:

Volts	Amperes	K.W.	P.F.
218	210	39.5	86

Fig. No. 15 shows largest butt welder ever made to date, and recently installed in the main works of the Truscon Steel Company at Youngstown, Ohio. It was made by the Federal Machine & Welder Company of Warren, Ohio. It has a welding capacity of 20 square inches. Hydraulic pressure is used to force material together after being brought to a welding heat. The following test was an average made on this machine "flash welding" steel plates S. A. E. 10-10; 30 in. x 3/16 in. total of 5⅝ sq. in.

Voltage	Current	Kva.	Kw.	Time in Sec.
222	432	93	84	9

Welding Steel 28 in. x ½ in. total of 14 sq. in. average.

Voltage	Current	Kva.	Kw.	Time in Sec.
218	1220	265	259	26

A test was made to determine the strength of butt welds as to tensile and shearing strength to original parent metal. Five samples two inches square were butt welded and machined to one inch square and three were put in tension and two in shear. All tests were pulled at a speed of ⅛ in. per minute.

No. 1 in tension failed in weld at 48,800 lbs.
No. 2 failed in weld at 52,300 lbs.
No. 3 failed back of weld at 50,100 lbs.
No. 4 in shear failed in weld at 51,500 lbs.
No. 5 in shear failed in weld at 50,300 lbs.

These tests indicate that the ultimate shearing strength of such a weld closely approaches the ultimate tensile strengh.

Pieces of soft steel 3/16 in. thick and 5 in. wide, with an ultimate tensile strength of 56,150 lb. were butt welded and pulled with the following results:

Test No.	Manner of Failure	Lbs.	%
1	One-half in. plate and one-half in. weld	51,000	91
2	In plate just back of weld.....	52,000	93
3	In plate just back of weld.....	53,400	95
4	In plate just back of weld.....	52,000	93
5	In plate just back of weld.....	46,100	82
6	In plate just back of weld.....	51,900	93

On six samples of spot welded single lap-joint sheets of 14 gauge steel, 3 in. wide, welded with a 5/16 in. spot, the average at which the welds pulled out was 4480 lb.

The ultimate tensile strength of a piece of plate of 14 gauge was 64,500 per sq. in., the ultimate, shearing load per weld (two spots with an area of 0.0742 sq. in. each) average 8,942 lbs., approximate total welded area, .01484 sq. in. This gives an ultimate shearing strength per 1 sq. in. of weld of about 60,200 lbs. On steel ⅜ in. thick and 2 in. wide, welded with a spot having an area, measured with a planimeter of 0.476 sq. in., the failure under pull was at 34,650 lb. Examination of the welds showed them to be under both a tensile and a shearing action. A piece of the same steel tested for ultimate strength, failed at 66,800 lb. per sq. in. This shows that the weld was stronger than the original metal.

The final conclusions drawn from these tests, are that, in general, the ultimate tensile strength of a properly made butt—or spot weld, is about 93 per cent of that of the parent metal, and the ultimate shearing strength of a properly made butt—or spot-weld is also about 93 per cent.

Discussion: Developments in Electric Maintenance Shop Practice

(Continued from page 596).

Jno. C. Reed*: Those of you who are familiar with Steelton probably know I have been striving for 20 years to get adequate facilities to do my work, and what I say is more a matter of opinion than a matter of proven facts and may not be of any value. About 20 years ago, when I was first starting out in the game, I was called into consultation and started to give my opinion. The manager said he did not care to hear my opinion but that what he wanted to know is what I knew about it. This is in a large part my opinion.

We do not have a good central shop, which to us means a great deal of disadvantage. However, we do the best we can, and so far we have managed to get away with it. We clean our apparatus principally outside. We have a Ford tractor which brings the apparatus to the shop, rather than by means of a car, and clean it off on the outside by means of air, and after bringing it into the shop, clean it principally with gasoline. When it comes to testing, it depends on what you can see about it; frequently it comes into the shop without any great need of testing other than some experience in good eyesight. But where that is not reliable, we do make tests on armatures to determine what is to be done. We find in rewinding armatures that, with about 90 per cent of the wire wound armatures coming into the shop, the best thing to do is to rewind and use new coils. With bar-wound, we get by with probably 70 per cent. When it comes to testing the equipment afterward, I would advocate running test, but in many plants, as in our own, this would not be practical because we have too many types and sizes of motors to make running tests of everything we have. However, where we have a complete motor brought in we do give that a running test, although not a load test.

Repair of armature shafts. My problem is practically the same as Mr. Standing's, although we do straighten some shafts where it would necessitate tearing down a motor and scrapping the coils. We do straighten those and they give very good service. We repair a great many damaged commutators and get satisfactory results.

As to the increased service from dipping and baking, I have faith in the general scheme of dipping and baking. I do not think it is open to argument that it isn't a good practice to pursue.

I do not know that I have anything new in regard to preventing breakage of wire-wound colis, but our practice is to interlace with linen tape and band to the commutator as close as possible, and we also fill up the neck so there is an insulated seat to rest on.

As to worn journals, we weld and turn them and obtain satisfactory results. Same thing applies to pinions and bad keyways; all welded up and remachined.

Assembled bars or complete commutators. About 50-50 I would say in that respect. If commutator core is bad or anything like that we buy complete commutators. Also carry assembled commutators; also repair a good many of them. Undercutting commutators: We follow that practice entirely, and I do not see that undercutting is not practical in all cases.

As to the use of high-grade brushes, that is a matter of opinion, but I believe high-grade brushes pay in all cases. As to permissible radial wear on d.c. armatures, we use 32-in. fiber feeler usually to test out—a rule-of-thumb method, but it works out satisfactorily.

With induction motors we use gauge. In the first place we use sight; if we can't see through we use gauge. If we can't get gauge through we start something. This thing of finding a quick way of doing things in radial bearing: there sin't any quick way of doing it. I presume our practice is like that of everybody else. Place a bar under the pinion to see what movement you have got. I do not know of any other way of telling.

As to the matter of rebabbitting shells, we use a lead base metal and don't do any tinning for that reason. We do sometimes bore or core holes in the shell to hold the metal, or score it so as to hold the metal. In handling this metal we use it over and over again until the foundry which does the babbitting does not think it is good enough to put in an armature bearing and puts it in a back bearing; but there are some types of lead base metal which you can't use over and over again. I do not know how much you don't know about bearing metal, but I will say right here there is a whole lot I do not know. We thought at one time we could make a bearing metal as good as the manufacturers, so we got the analysis, but we did not get the metal—like the old lady baking the cake. I have not found any bearing of the babbitt type with which you do not get oil inside the motor sooner or later, especially in a reversing motor.

Regarding the manufacture of coils: We have for some years reinsulated our bar wound coils and find they give the same results as those purchased from the manufacturers. You have a coil already formed, have to straighten it a little bit, and you can reinsulate that coil and do it cheaper than you can buy new coils; so we follow that practice. Also have equipment for manufacturing wire-wound coils, not with the idea of manufacturing all of our wire-wound coils, but where one has many kinds of motors it necessitates a large stock in the storehouse, and I feel that we can greatly reduce our stock of coils and have less investment in equipment to make these coils than we will have in the storehouse if we carry all kinds of coils in stock; so I think it is a good piece of equipment to have standing around, so we can go ahead and make them when necessary. After winding we don't use any special effort in cleaning except to wipe them carefully. As to dipping, we dry thoroughly before we dip. Most satisfactory baking temperature is about 225 deg. F., and we bake about eight hours.

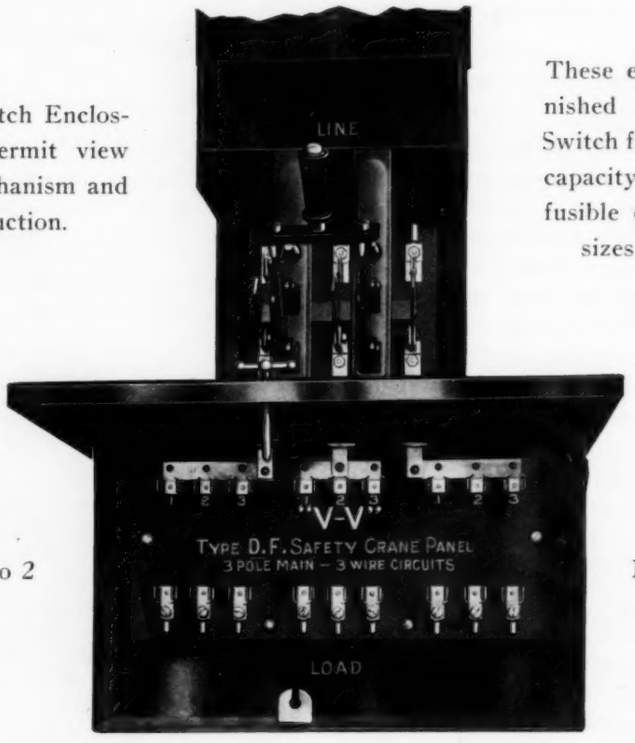
*Electrical Engineer, Bethlehem Steel Company, Steelton, Pa.

"V.V."

SAFETY SWITCH DEVICES

SAFETY CRANE AND DISTRIBUTION PANEL

Cut shows the Switch Enclosure removed to permit view of the interior mechanism and sturdy construction.



These equipments can be furnished with any size Main Switch from 100 to 1500 ampere capacity, and with as many fusible circuits as required of sizes 30 to 1500 ampere capacity.

Made for 2 to 2, 3 to 2 and 3 to 3 wire installations.

Made for 125-250-500-600 volt. N. E. C. S. fuses.

Illustration shows a standard 3 to 3 Wire Fuse Distribution Panel having a 100-Ampere, 3-Pole Main Switch

This arrangement insures safety to the operator, as the door is interlocked with the main switch, which must be thrown "OFF" before access to the fuses is possible. The fuse door must likewise be closed again before the main switch can be thrown in the "ON" position.

V. V. FITTINGS COMPANY

MAIN OFFICE AND WORKS
PHILADELPHIA, U. S. A.

New York Office: 50 Church Street

Chicago Office and Warehouse: 710 West Jackson Blvd.

A BRUSH OF PROVED QUALITY

Use

N C C

259

On

Undercut Commutators of
DC side of Rotary Converters
DC Generators
DC Motors
AC Commutator Type adjustable speed motors

and secure minimum commutator wear, cool operation with splendid commutation and consequent increased efficiency.

National Pyramid Brushes

Manufactured and guaranteed by

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Canadian National Carbon Co., Limited, Toronto, Ontario

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NEW YORK, N. Y.
237 East 41st St.
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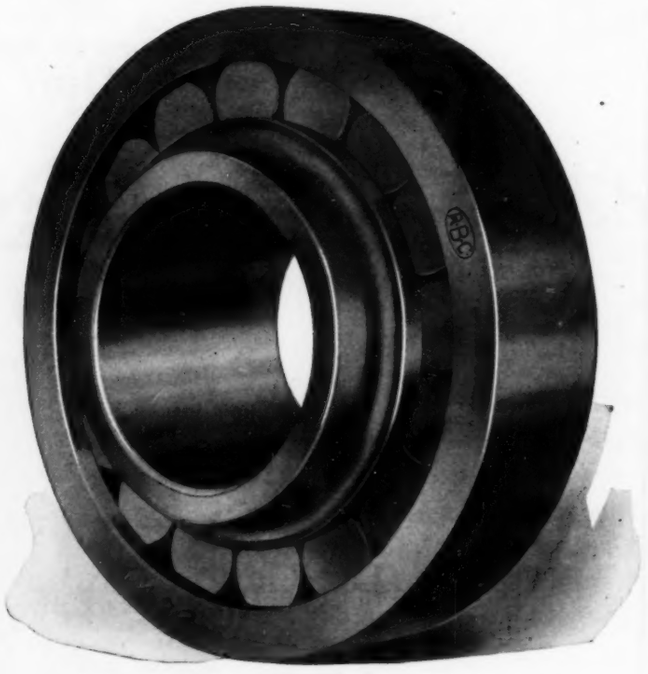
BRINGING UPKEEP DOWN



The following statement regarding actual operating conditions with

ROLLWAY BEARINGS

is the conclusion arrived at by an Electrical Engineer who has had eight years' experience with our product.

> "From my experience with these bearings I have found that their use results in reduced electrical repair, diminished commutator wear, reduction of band breakage, less pinion maintenance, reduced expense for inspection and lubrication and less delay time charged against the electricians."

Let us explain how we can do the same for you.

Made in

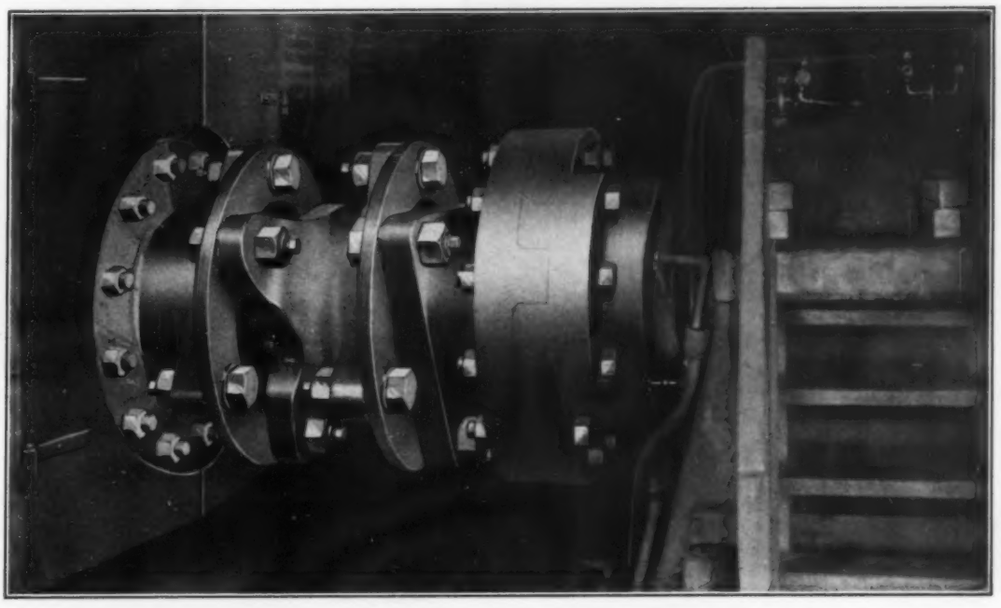
SYRACUSE, NEW YORK, U. S. A.

by

ROLLWAY BEARING CO., Inc.

THOMAS FLEXIBLE COUPLINGS

FOR MAIN ROLL DRIVES



Thomas Mill Type Coupling on 84" Plate Mill, 2500 H.P., 235 R.P.M.
Youngstown Sheet & Tube Company

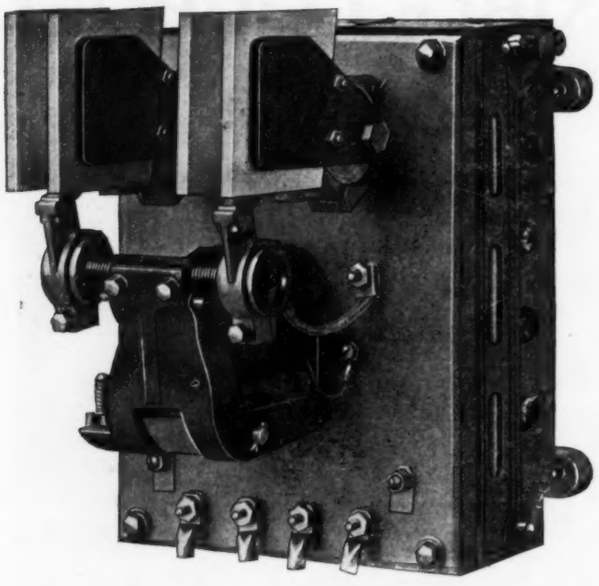
Above coupling and another on the 5,000 H.P. 197 R.P.M. 132" plate mill drive at this same plant have operated a total of six years with absolutely no maintenance charge.

No sliding or wearing parts
No loosely connected members
No frictional resistance to end float
No lubrication
Three very accessible bolts, removal of which frees either end of drive

The Thomas coupling is the only mill spindle which has these features. The first two are the most important, as a "tight" drive eliminates all backlash and prevents the hammering action, which is so destructive to gears, bearings and shafts. The net result is an immediate reduction in maintenance costs.

Thomas Flexible Coupling Co., Warren, Pa.

SALES OFFICES: Pittsburgh Chicago Cleveland Philadelphia Boston St. Louis New York Springfield



OHIO MAGNET CONTROLLER

We have seen Lifting Magnets make as high as six lifts per minute equal to say three hundred per hour or one million per year and each time the switch opens the magnet circuit it breaks a circuit of two to three thousand volts caused by the inductive kick of the magnet .

The Controller is the tail of the magnet but each time the magnet drops its load that tail gets a vicious wag and not only that, but unless the controller functions properly, the big kick voltage will get out on the line and cause burnouts of lamps, motors, coils and other electric devices which may be connected on that same system.

Truly the Magnet Controller has an important duty to perform and the Ohio pictured above does just that and furthermore, will give immediate notice of anything wrong in the Magnet circuit.

Electrically the Controller closes the magnet circuit for "lift" and when the master is thrown to off or center, the magnet circuit is opened for "drop" but permanently connected across the magnet terminals is an iron clad protective resistance which converts the big kick voltage power into heat, reduces the arc at the control contacts to a harmless minimum and thus protects the insulation of the magnet and all other machines connected and prolongs the life of the controller itself.

The application of this protection does not depend upon the skill of the operator; it is automatic and always on duty.

For "Quick Drop of the Load" the master handle is pushed through and limited reverse current is applied to the magnet causing the magnetism to drop to zero and the load to drop promptly. This is specially important for fast work or where high carbon materials are being handled.

Mechanically, it is desirable that the magnet circuit have a double break, both contacts opened simultaneously, and this result can only be insured by the double pole switch and to secure long life in the Ohio the cross arm is a heavy steel bar and the spring cushions the closing blow so that the heavy lavite insulator on each end of the cross arm is practically everlasting.

The four main contacts are duplicates and could easily be reproduced in any shop. The blowout coils are perfectly shielded and the heavy arc shields turn up for inspection or quick renewal of the main contacts.

Reverse for quick drop is secured through the master and by a strong auxiliary at lower left of the main contact arm and all contacts have a decided wipe and are thus self-cleansing.

Resistance consists of five strips of armoured Cromalox capable of working red hot but only just warm in this application and should one of them open in service the magnet would still work safely until it was replaced.

Physically, if mounted on a wall the controller requires a space 16 in. high, 14½ in. wide and 14 in. deep. Resistance and internal wiring can be inspected or replaced by one man who loosens the two thumb nuts above; opens the controller about the hinge pine below and does not have to disturb the main connections or the wall mounting.

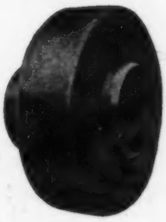
The New Ohio Magnet Controller is the net result of much study, trial and constructive suggestions on the part of magnet operators. It will save you time, money and annoyance.

OHIO reliable MAGNETS

The

Ohio Electric & Controller Co.

Cleveland, Ohio



Isn't That a Dandy Looking Flexible Coupling?

That's a Nuttall Type C—Safety first, entirely enclosed, spring buffers, good for 85 to 2700 H.P., 440 to 3600 r.p.m.—1½" to 15½" shafts, outside diameters 6½" to 52". May we send you booklet describing our couplings in detail? We make two other types.

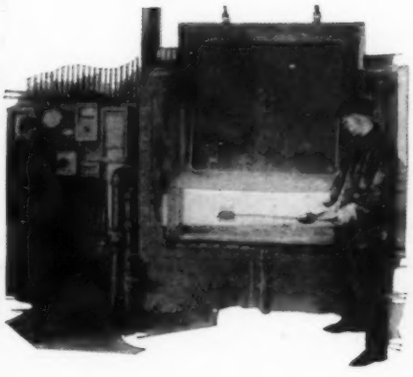
Did you ever hear a quiet street car?

Just listen when some of Pittsburgh's new yellow Crosstowns pass, but don't stand on the track without looking—they sure do slip up on you. Any machine, crane or motor in your plant can be made just as quiet—here's how →

Complete literature or an engineer at your service without obligation.

Helicals

—the Gears that made Nuttall famous.



Just as brass and iron superseded wood and stone—just as steel superseded iron, heat treated steel has superseded ordinary steel, and the Nuttall heat treating plant has turned out some of the most exacting work in the world; oil, gas and electric furnaces, pyrometers, Brinell and Shore testing machines, water, brine, oil, chemical and BP quenching tanks. It's a wonderful plant and you ought to take advantage of its facilities.

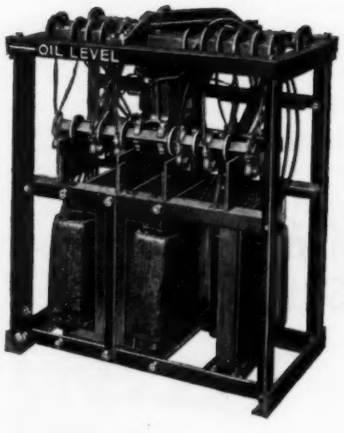
R.D. NUTTALL COMPANY
PITTSBURGH PENNSYLVANIA

Philadelphia Office
420 Land Title Bldg.

Chicago Office
2133 Conway Bldg.

Nuttall

EC HIGH VOLTAGE DUST VAPOR WEATHER FOOL FIRE PROOF &M COMPENSATOR



This is a push button operated, automatic high voltage Compensator.

It is entirely enclosed, as the top view shows.

It is oil immersed.

The case is dead electrically so that it is not necessary to build an enclosing case.

The push button operates on a low voltage circuit, which circuit is independent of the high voltage circuit. There is no danger of the operator coming into contact with the high voltage.

It is entirely automatic. When the start button is pushed the motor is started on a low voltage obtained from the transformers in the Compensator. After the motor has accelerated to a speed where it is safe to throw it across the line, the Automatic Compensator takes care of this operation.

The Overload Device protects against overloads at all times and prevents any damage due to single phasing.

Write for Bulletin 1047.

THE ELECTRIC CONTROLLER & MFG. CO.

CLEVELAND, OHIO

BIRMINGHAM - BROWN-MARX BLDG.
CHICAGO - CONWAY BLDG.
CINCINNATI - 1ST NATIONAL BANK BLDG.
DENVER - 3535 WALNUT ST.
DETROIT - DIME BANK BLDG.
LOS ANGELES - THOMAS MACHINERY CO. AMERICAN BANK BLDG.
NEW YORK - 50 CHURCH ST.
PHILADELPHIA - WITHERSPOON BLDG.
PITTSBURGH - OLIVER BLDG.
SAN FRANCISCO - CALL BUILDING
SEATTLE - 524 1ST AVE. SOUTH
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Strength –Power– Economy

LIFTING, hauling, carrying, dumping, in and out tight aisles, around sharp corners, up steep ramps, Baker industrial tractors and trucks meet a startling range of material-handling requirements.

Sturdy construction, ease of handling and freedom from trouble, combined with the saving in time and man power over hand methods, make these machines a decided economy wherever heavy, bulky material needs shifting.

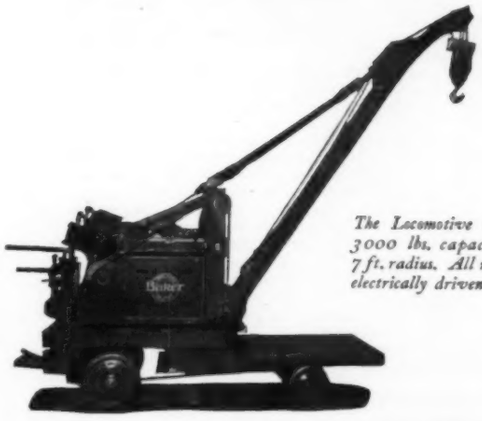
The machines here illustrated include but a few of the types in widest use. There are many other models for each individual service.

Write for complete catalog of all Baker models or ask our recommendations for particular installations.

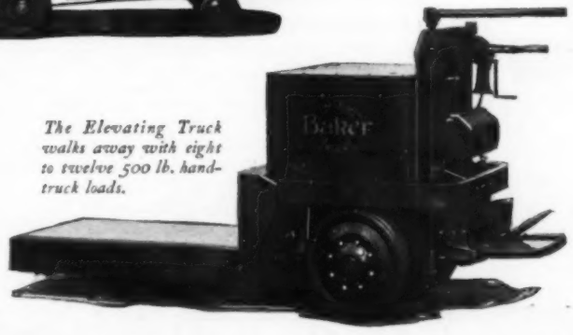
Baker Industrial Division
THE BAKER R&L COMPANY
CLEVELAND, OHIO

The 4-wheel Tractor combines brute strength with tractive capacity, speed and driving ease.

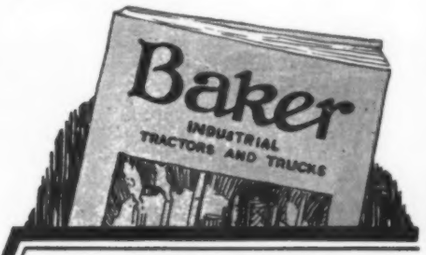
The Hy-Lift Truck lifts, carries and stacks heavy packages with ease.



The Locomotive Crane. 3000 lbs. capacity at 7 ft. radius. All motions electrically driven.



The Elevating Truck walks away with eight to twelve 500 lb. hand-truck loads.



ELECTRIC TRACTORS AND TRUCKS

TRADE-MARK REG. U.S. PAT. OFF.

Baker

Baker Industrial Division
THE BAKER R&L COMPANY
CLEVELAND, OHIO

Please send your complete catalog to

Name _____

Position _____

Railroad _____

Address _____

City and State _____

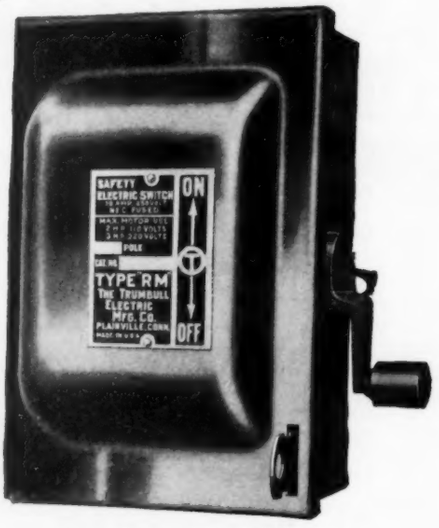
Just the Switch for use with small motors in steel mills or for use on lighting circuits.

—the "R.M" Switch

Small Size

Full Safety Switch

30 Amperes—250 Volts



Box Closed—8" x 5¼" x 4½"

Box open. Fusible
Fuse block and shield are reversible

1. The Switch box is very compact (2 Pole 4½ x 8", 3 Pole 6¾" x 8"), meeting a long-felt need for a rugged, full safety article for installation where size is a prime factor.
2. Removing two screws enables entire Switch and fuse block to be takes from box. Thus, entire box space is available for connecting conduit and running wires.
3. Quick make and quick break with Type "A" interlock.
4. Handle operates a compression spring on same principle as rest of Type "A" line. Handle would operate Switch if spring should fail.
5. Constructed on double break principle. Blades are carried by a rotor of moulded material, actuated by the cam of the Q.M. and Q.B. mechanism.
6. When blades are in "off" position they throw into deep narrow slots in the base and thus effectually snuff out any arc which might have a tendency to follow.
7. The Switch base, fuse block base, and rotor are all of high grade moulded material of unusual strength, and will stand much abuse in handling.
8. The fuse block mounted over the Switch base, brings fuses directly to the front in most accessible position. Dead front construction.
9. Line terminals on Switch base are accessible without removing fuse block. Load terminals are on fuse block above the line terminals. Thus on fusible Switches, both line and load terminals are on same end of box.
10. By reversing position of fuse block, line and load connections can be made at the bottom of Switch if desired. We regularly furnish the Switch top connected.
11. A shield attached by one screw covers line terminals, preventing any possible contact with live parts. This shield will fit only on terminal end, top or bottom, depending on position of fuse block.
12. Switches furnished fusible or no fuse. On no-fuse Switch the fuse block is omitted and line can be connected at either top or bottom, as desired.
13. This Switch gives the trade a very high grade article. Quick make and quick break, with full safety features, at an exceedingly low price.
14. 440, 50 volts Switches. 2 and 3 Pole will shortly be placed on the market.
15. Handle is a ribbed steel punching with cast iron knob—practically indestructible.

NO FUSE 250				FUSIBLE 250 V.			
Cat. No.	Pole	Volt	List Each	Cat. No.	Pole	Volt	List Each
46221	2	250	$4.80	92221	2	250	$5.50
46321	3	250	6.00	92321	3	250	7.00
46421	4	250	8.50	92421	4	250	9.50

We can furnish 3 p. fusible switches with solid neutral at regular price on request.

Discount Trumbull Schedule C

You can get all the details of the complete Trumbull Line by asking your jobber for Bulletin No. 5.

The Trumbull Electric Mfg. Co.

Plainville, Conn.

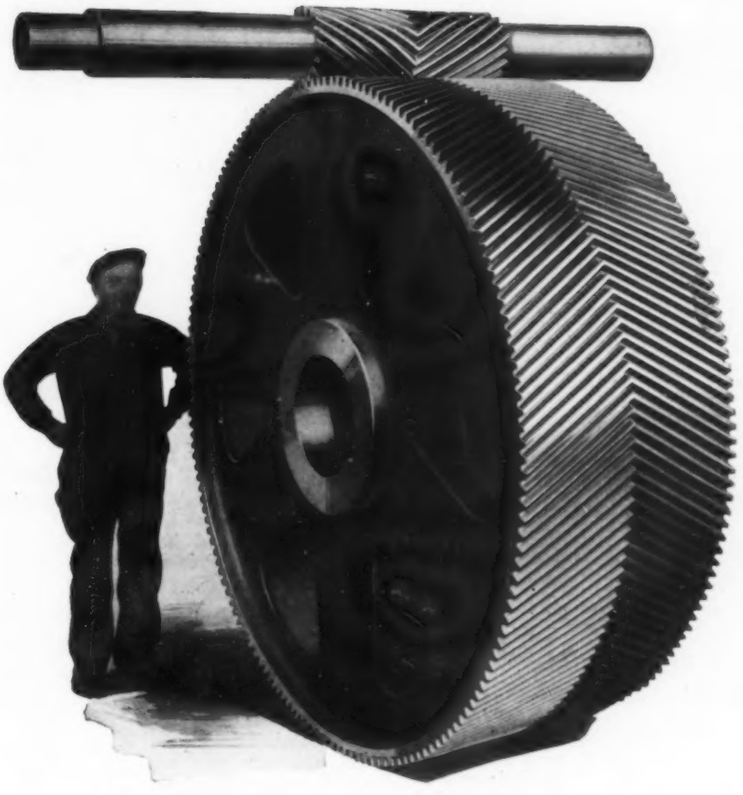
New York 114 Liberty St. | Boston | Chicago 2001 W. Pershing Road | Philadelphia | San Francisco 595 Mission St.

Atlanta, Ga.

Don't Bother With Laborious Specifications

Just Write In

"SYKES GEARS"



The Herringbone Gear

WITH A BACKBONE

GENERATED FROM THE SOLID—CONTINUOUS TEETH—SHARP APICES

FARREL FOUNDRY & MACHINE CO.

BUFFALO, N. Y., U. S. A.

THE STANDARD OF COMPARISON

The Delta Star

UNIT TYPE

Responsibility of Standardization

DURING the last few years we have been repeatedly impressed with the fact that standardization carries with it a responsibility of which we were not fully aware, when some twelve years ago, we embarked upon our now well-known venture of creating order and scientic proportions out of the chaos existing in the high tension equipment field.

We knew that standardization should involve only essentials that are not changed by the fickles of fashion nor by natural development along scientific lines of the particular part in question. By way of illustration, when our creators of Unit Type standardized on outdoor insulator units, they did not select any particular make, shape or style of insulator body. Instead of being guided by such a *changeable* quantity as porcelain design, they went clear back to Euclid and standardized on a *dimension* — the distance from top of cap to bottom of pin. In a similar way, the distance between insulators on switching equipment were determined — not by the appearance of any particular make of insulator—but by a *definite relation* which we discovered should be maintained between an adopted flashover value of insulator and a safe air gap separation.

Our contemporaries have produced an abundance of printed evidence to convince us that Delta-Star is now an acknowledged "STANDARD OF COMPARISON." Much as this elates us, it nevertheless creates a feeling of unwished for responsibility, for to associate certain dimensions with certain operating voltages may not result in safe construction unless one knows the *facts* behind the figures—any more than a cemented switch insulator would be a desirable product *unless* mechanical and electrical features are properly balanced and the cement mixed with brains.

Responsibility of Standardization

DELTA-STAR ELECTRIC CO.

2400 Block Fulton St Chicago, Illinois

Birmingham, Ala., 827-830 Brown-Marx Bldg.
Boston, Mass., 294 Washington St.
Buffalo, N. Y., 595 Ellicott Square
Charleston, W. Va., The Eng'g Service Co.
Columbus, Ohio, 600 Joyce Realty Bldg.
Detroit, Mich., 708 Ford Bldg.
Indianapolis, 518 Trac. Term. Bldg.
Kansas City, Mo., 301-2 Dwight Bldg.
Knoxville, Tenn., Holston Nat'l Bank Bldg.
Los Angeles, Calif., I. W. Hellman Bldg.
Minneapolis, Minn., 940 Security Bldg.
New York, N. Y., 25 Broad St.
Orlando, Fla., Cornell-Mathews Co.
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Pittsburgh, Pa., 934 Union Trust Bldg.
Rochester, N. Y., 119 Main St., E.
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San Francisco, Calif., 193 Second St.
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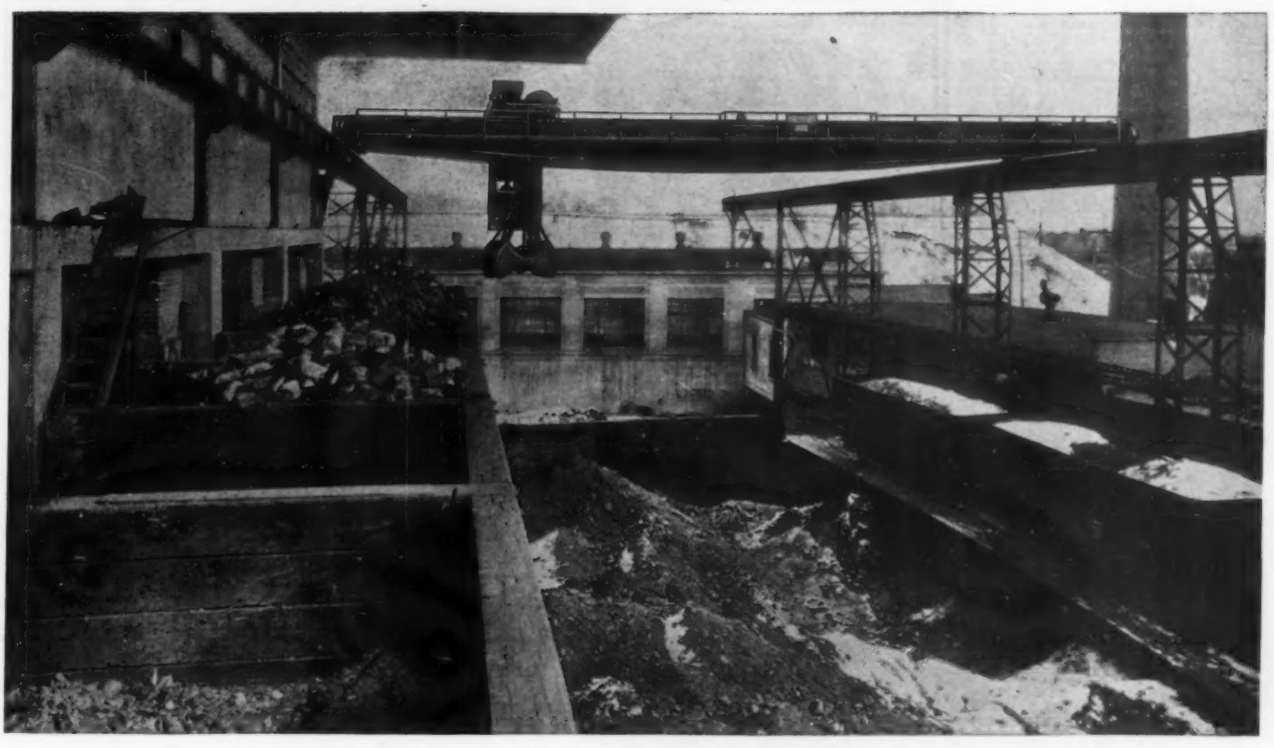
Syracuse, N. Y., City Bank Bldg.

UNIT TYPE CEMENTED SWITCH INSULATORS



P & H Combination Grab Bucket and Magnet Type Crane, for handling coke, limestone, slag, pig and scrap iron, etc.

You Can Always Count on Steady Service and Low Maintenance Cost

The P & H Electric Traveling Crane with grab bucket and magnet for steel mill and foundry yard service, is built in accordance with the strict requirements of heavy duty.

These cranes are designed throughout with special attention to accessibility—bearings are bronze bushed and cast integral to insure alignment, through-bolts are used exclusively, shafts may be removed with gears in place and without disturbing other parts—all braking is accomplished electrically.

Bucket Operates Close to Runway Rails

The design of the P & H trolley permits picking up and depositing materials close to either runway rail, a valuable feature particularly where runways run parallel with building walls.

P & H Grab Bucket Cranes and Hoists are used by such companies as the Illinois Steel Co., Wisconsin Steel Co., The McKinney Steel Co., Wm. Wharton Jr. & Co., Tennessee Coal, Iron & R. R. Co., Weirton Steel Co., Whitaker Glessner Co., Crucible Steel Co., Inland Steel Co., Universal Portland Cement Co.

Our Bulletin 305 tells all about the quality of P & H design, materials and construction. A copy will be forwarded on request.

Crane and Hoist Division

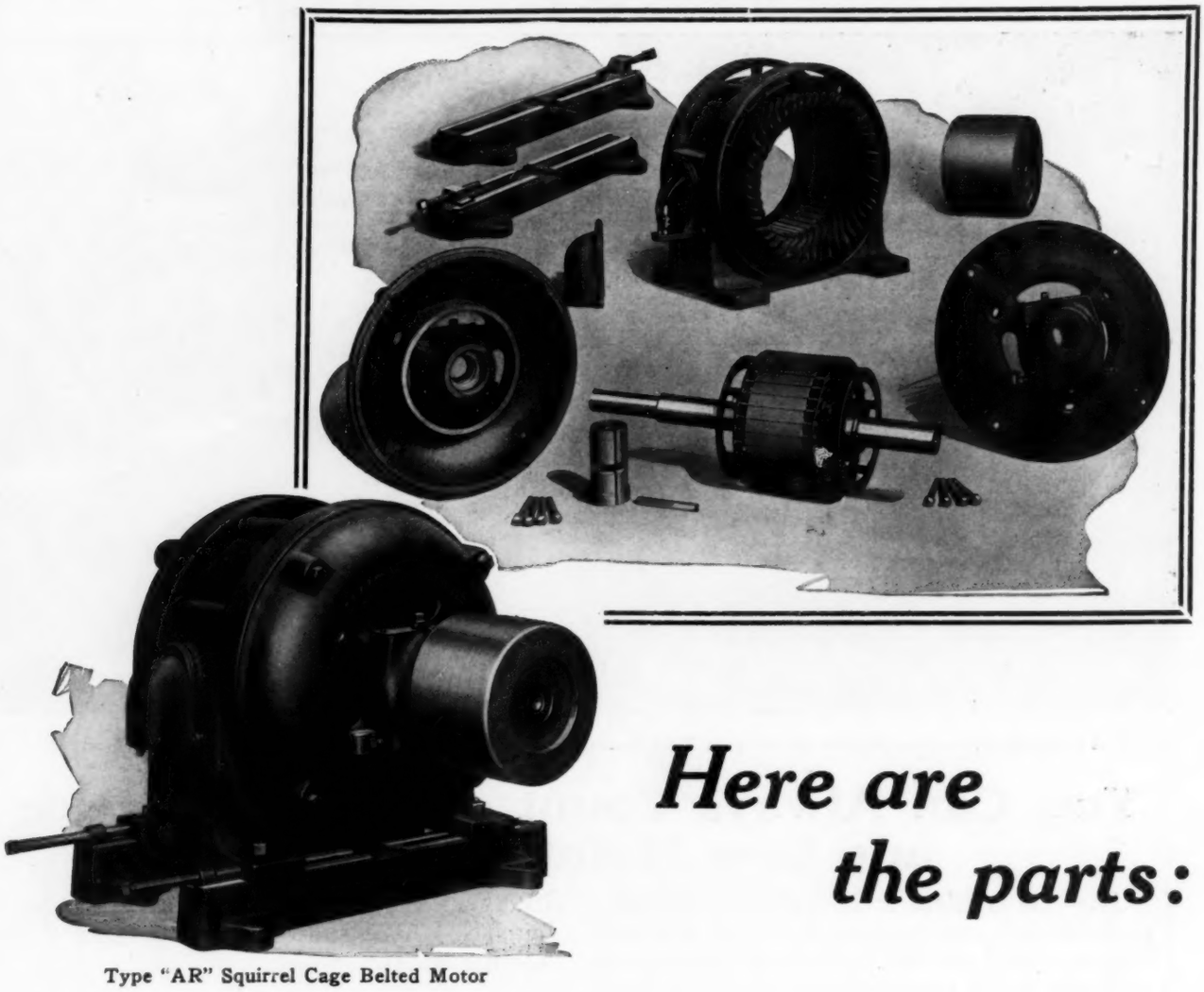
PAWLING & HARNISCHFEGER CO.

Established in 1884

3855 National Ave., Milwaukee, Wis.

New York	Chicago	Dallas	Pittsburgh
Atlanta	Portland	Seattle	Los Angeles
Detroit	Memphis	Philadelphia	San Francisco
Kansas City			

P&H GRAB BUCKET CRANES



Type "AR" Squirrel Cage Belted Motor

Here are the parts:

Above is shown a new Allis-Chalmers type "AR" motor disassembled. Note its simplicity. What you see above is the complete motor. Its lack of complexity is one of the features of the type "AR" which gives it its high service value.

Allis-Chalmers type "AR" motors are built of steel practically throughout. The stator end frames and feet are integral and made from electric steel castings. The rigidity resulting from this eliminates the possibility of broken end frames and feet.

By careful well balanced design, the use of selected materials and by good workmanship and construction, high efficiency over a large range of the working load with correspondingly high power factor have been attained in these new motors.

Built in capacities from ¾ to 200 H.P.

ALLIS-CHALMERS MANUFACTURING CO.
MILWAUKEE, WIS. U.S.A.

This is *your* book —not solely *ours*

Engineers and executives—prospective buyers of electric hoists—want specific information. That is why this new descriptive Catalog and Price List of Shepard Hoists is void of generalities.

33 different types of Shepard Floor Operated Hoists are shown, including an actual installation view of each and a description of how the user applied and uses the hoist—also how efficient, and consequently reduced cost, load-moving obtains in his establishment.

It is a book for YOU, suggesting many ways in which these hoists will save your money.

It points out the merits of Shepard design, contains complete data and gives capacities, prices, dimensions, and clearance drawing of each hoist—specific information to answer your questions, arranged in an easily accessible manner.

Send for your copy.

It contains 60 pages and is the most complete electric hoist book ever issued. Fill in and mail coupon, or attach to your letterhead.

Comprehensive Information
From America's Largest Manufacturer of Electric Hoists

Use Convenience Coupon

Shepard Electric Crane & Hoist Co.,
352 Schuyler Ave., Montour alls, N. Y.

Without obligating us send your new hoist book to:

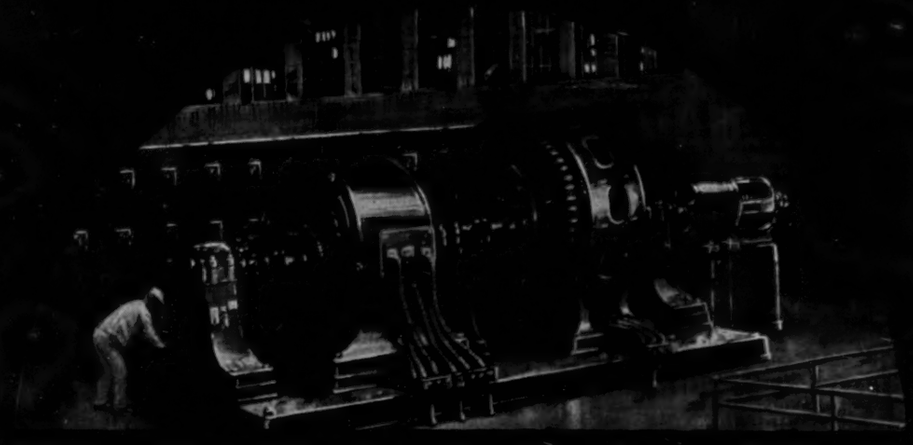
Name .....

Address .....

City and State .....

REG. U.S. PAT. OFF.

SHEPARD
ELECTRIC CRANES & HOISTS



ECONOMY *renewable* FUSES

INDUSTRIES using electrical energy save 80% annually in fuse maintenance costs when they install Economy renewable Fuses in the place of "one-time" fuse-equipment.

Economy Fuse performance is a matter of record—they were the first fuses using inexpensive bare renewal links for restoring blown fuses to their original efficiency to be *Approved in All Capacities* by the Underwriters' Laboratories.

Economy "Drop-Out" Renewal Links cost but little and make the restoration of a blown fuse the work of a moment only.

Your plant needs Economy Fuses. Investigate the quality of the electrical protection you now have from the standpoint of dependability, efficiency and economy.

Then order Economy Fuses installed.

For Sale by all leading Electrical Jobbers and Dealers.

ECONOMY FUSE & MFG. CO., Chicago, U. S. A.

Economy Fuses are also made in Canada at Montreal

PROTECTION

Protection, at any cost, must be had for the circuits of the modern steamship. If a circuit goes off, a signal may not work, the wireless may fail and expensive delays or even disaster may be caused.

When the William K. Field slid down the ways she carried a Buss Renewable Fuse in every clip. The William K. Field is the largest boat on the Great Lakes. Slipshod methods were not used in her design or construction. She was built for service and to stay in service. She must pay the utmost in profit on her investment. Buss fuses were selected because the engineers found that they give the best electrical protection at the lowest operating cost.

Experience has shown that whenever careful research has been made Buss Renewable Fuses were selected as best fitted to the needs of modern industry.

Let the facts speak for themselves—and to be sure you are right always specify Buss Fuses.

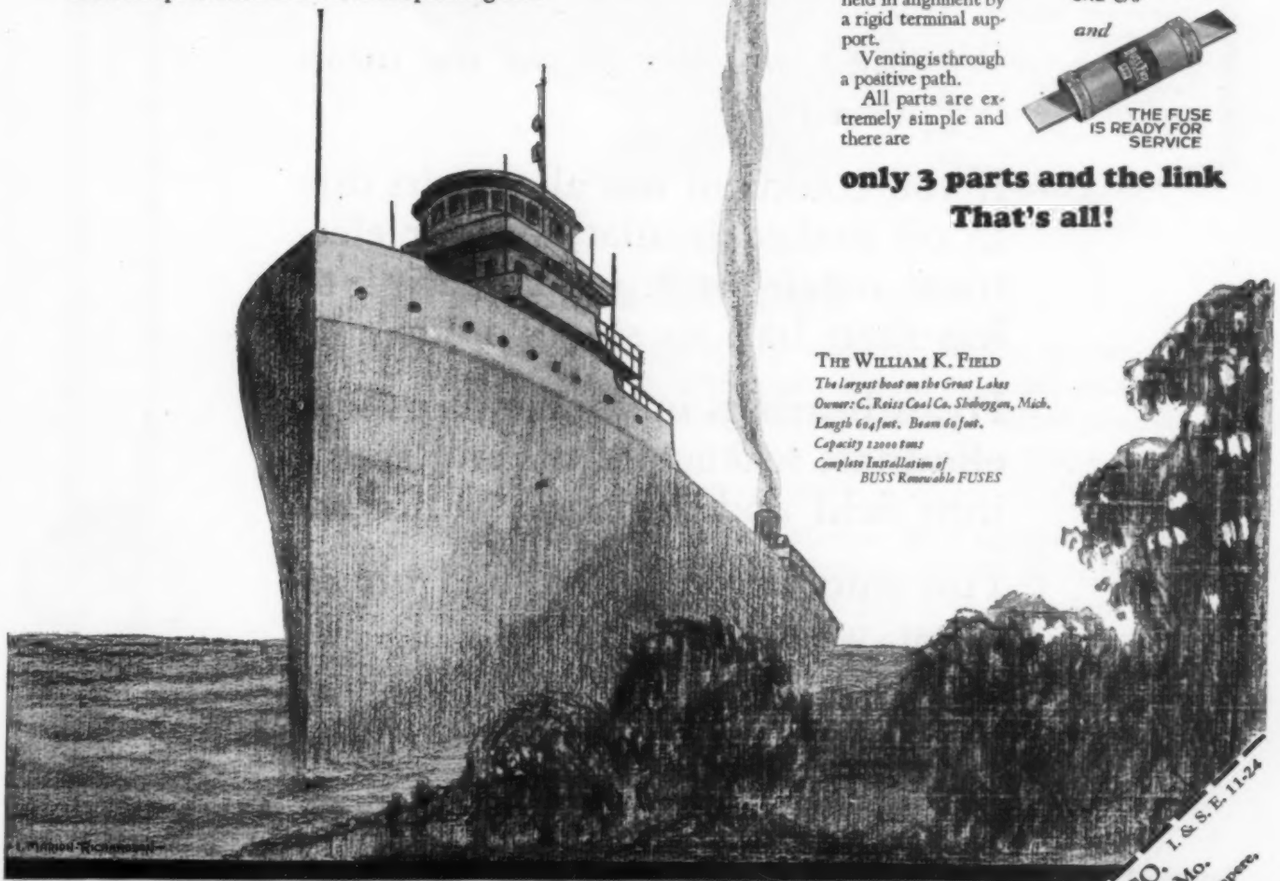
The Buss Knife Blade type Renewable Fuse has but three parts and the link to be handled in renewing.

The terminals are held in alignment by a rigid terminal support.

Venting is through a positive path.

All parts are extremely simple and there are

only 3 parts and the link
That's all!



THE WILLIAM K. FIELD
The largest boat on the Great Lakes
Owner: C. Reiss Coal Co. Sheboygan, Mich.
Length 604 feet. Beam 60 feet.
Capacity 12000 tons
Complete Installation of BUSS Renewable FUSES

BUSS FUSES

APPROVED IN ALL TYPES AND SIZES

TRADE Buss Fuses ELECTRICITY'S SAFETY VALVE MARK REG. U.S. PAT. OFF.

"ELECTRICITY'S SAFETY VALVE" MEANS

BUSSMANN MANUFACTURING CO. I. & S. E. 11-24
3819 North Twenty-Third Street, St. Louis, Mo.
Without obligation, send me for examination sample 100 ampere, 250 volt Knife Blade Type BUSS Renewable Fuse.

Name / Position
Company
Street
City
State

HYATT ROLLER BEARINGS FOR ELECTRIC MOTORS

Fewer Repair Jobs

HOW many motors, month in and month out, pass through your electrical shop for repairs?

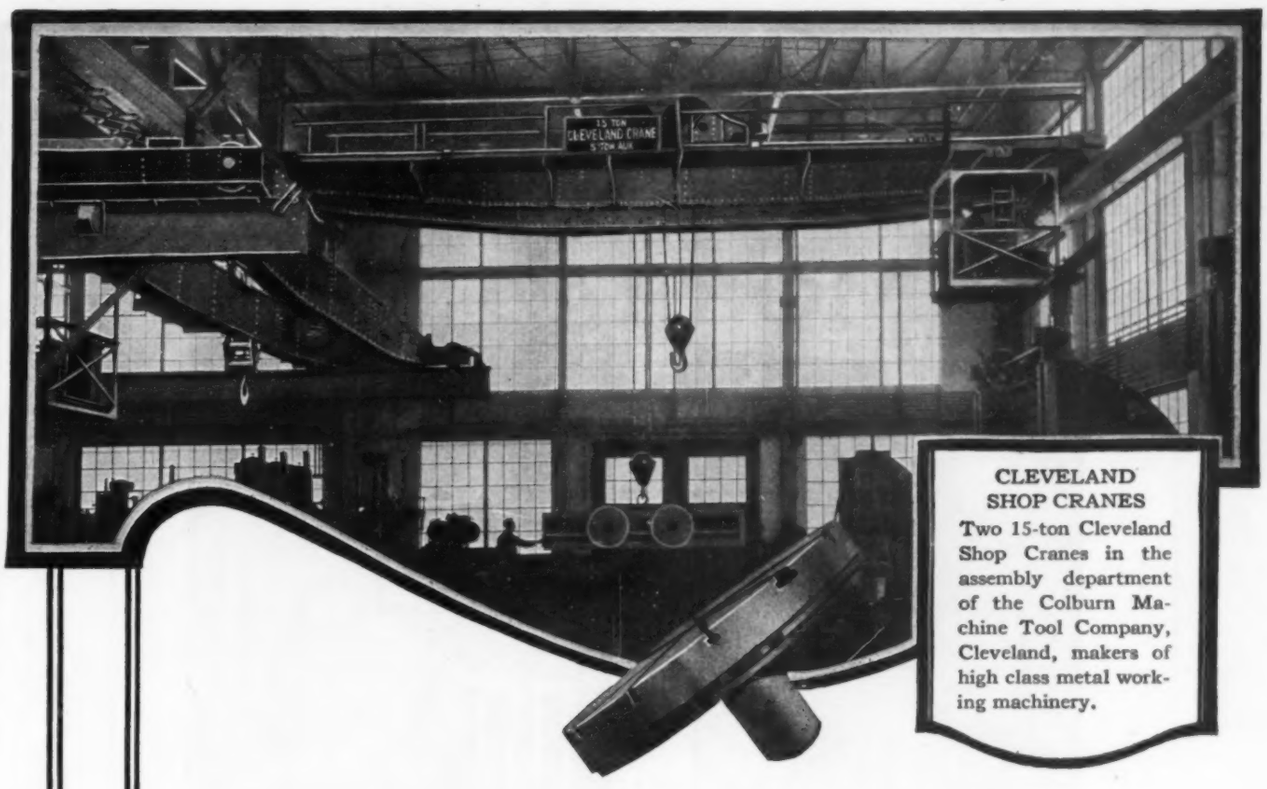
Wouldn't you like to cut the number in half?

If you could cut out all repairs due to oil soaked insulation your electrical repair work would shrink to less than half its size, wouldn't it?

Hyatt bearings in your motors will eliminate leakage of oil and grease into field and armature windings.

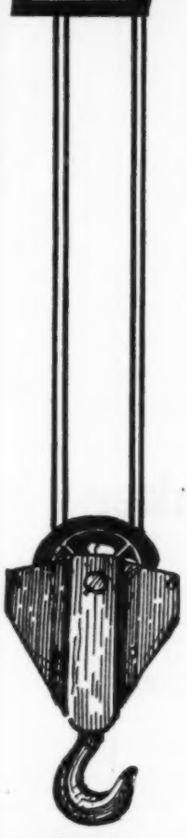
Full information furnished on request, without obligation.

HYATT ROLLER BEARING COMPANY
NEWARK, NEW JERSEY



CLEVELAND SHOP CRANES

Two 15-ton Cleveland Shop Cranes in the assembly department of the Colburn Machine Tool Company, Cleveland, makers of high class metal working machinery.



You Need a Crane!

Some executives know their machines are not producing the maximum—others have grown content to make *small sizes* and leave the larger units to competitors. When progress in your factory stops and you operate under either of these limitations—*you need a crane!*

Every Cleveland Crane, whether light or heavy capacity, receives the same individual attention of our designing engineers. Each is assembled and tested in our plant before loading for shipment. Every Cleveland Crane is built to do the work expected of it in service.

THE CLEVELAND CRANE & ENGINEERING CO.

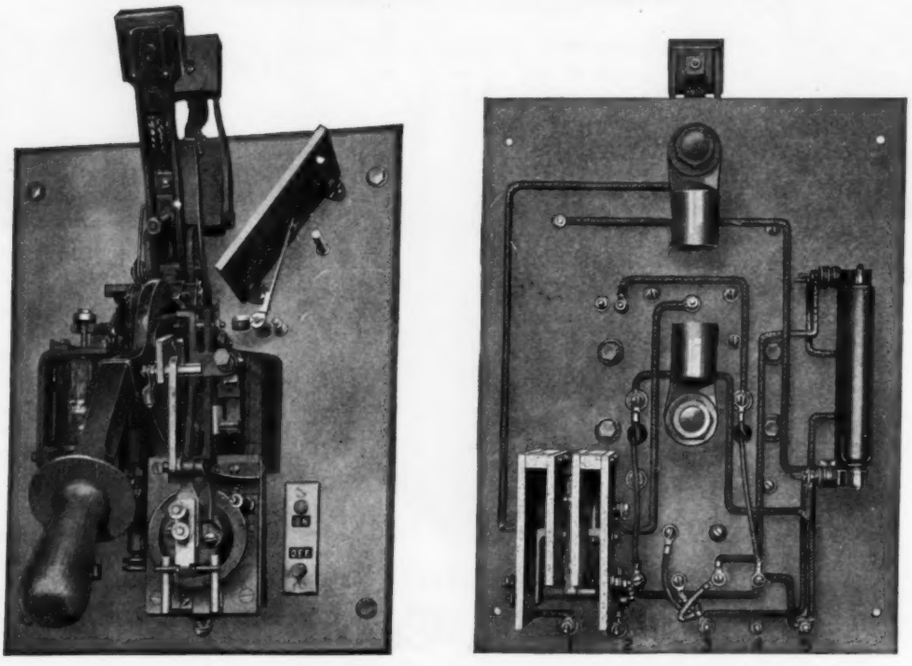
New York City
30 Church St.

WICKLIFFE OHIO.

Pittsburgh
511 Farmers Bank Bldg.

CLEVELAND CRANES

A Manually Operated Circuit Breaker
That Recloses Automatically



Front and Rear Views, Type "AHM" 600-Ampere Automatic Reclosing Circuit Breaker
With Removable Handle for Manual Operation

or

An Automatic Reclosing Circuit Breaker
That May Be Operated Manually

either way

This Circuit Breaker Embodies All That Is to Be Had in a Circuit Breaker
and Assures You High Grade Circuit Breaker Protection
At All Times and Under All Conditions

With That Refinement in Service That Can Be Had Only With

The Circuit Breaker with Brains

Bulletin 314-F Gives Details.

THE AUTOMATIC RECLOSING CIRCUIT BREAKER CO.

COLUMBUS, OHIO

PITTSBURGH: 1815 Oliver Bldg.
ST. LOUIS: 401 National Bank of Commerce Bldg.
WILKES-BARRE, PA.: 816 Miners Bank Bldg.
CHARLESTON, W. VA.: 314 Moore Building

"LE CARBONE" CARBON BRUSHES

Standard of Quality and Uniformity

They are supplied not alone to suit type of machine, but your operating conditions.

Guaranteed Without Argument.

Real Engineering Service.

W. J. Jeandron, 345 Madison Ave., New York

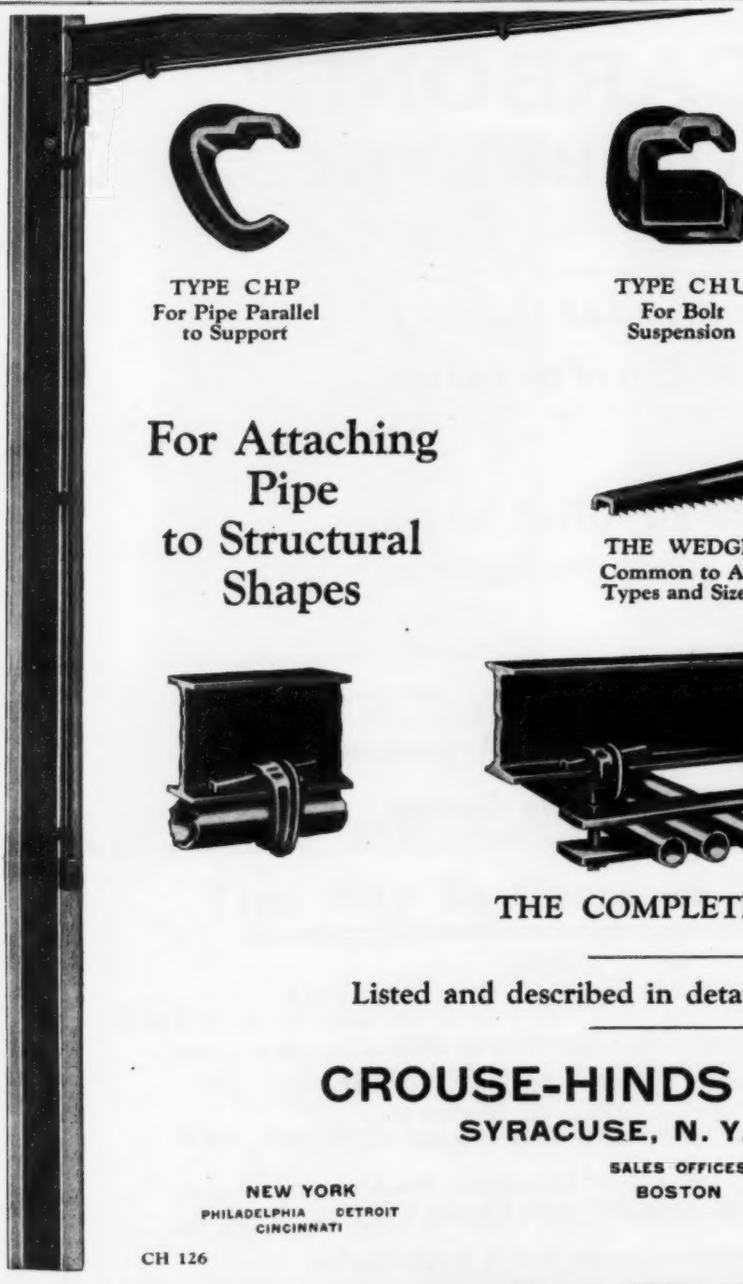
Pittsburgh Office, 634 Wabash Bldg.
W. P. POYNTON, Electrical Engineer

San Francisco Office, 525 Market St.
W. R. CATCHING, Sales Engineer

Chicago Office, 1657 Monadnock Block
A. M. RAMSEY, Sales Engineer

Canadian Distributors:. Lyman Tube & Supply Co., Ltd.
Montreal and Toronto

"Wedgtite" Pipe Hangers



TYPE CHP
For Pipe Parallel to Support

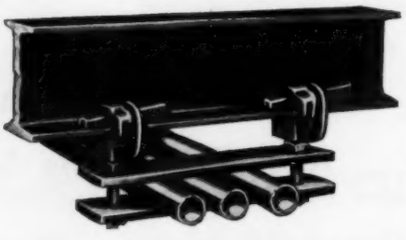
TYPE CHU
For Bolt Suspension

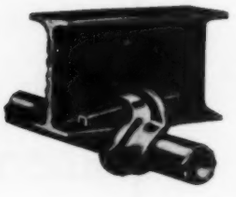
TYPE CHR
For Pipe at a Right Angle to Support

For Attaching Pipe to Structural Shapes

THE WEDGE
Common to All Types and Sizes

A Hammer the Only Tool Necessary





THE COMPLETED JOB

Listed and described in detail in Bulletin 2058

CROUSE-HINDS COMPANY

SYRACUSE, N. Y., U. S. A.

SALES OFFICES

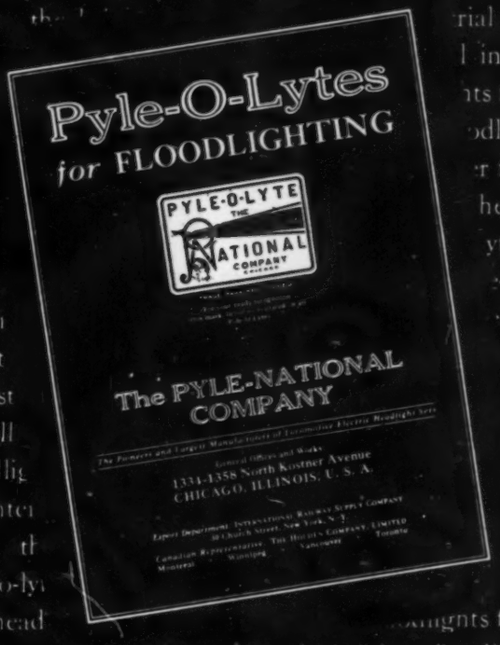
NEW YORK
PHILADELPHIA DETROIT
CINCINNATI

BOSTON

CHICAGO
ST. LOUIS MINNEAPOLIS
SAN FRANCISCO

CH 126

CROUSE-HINDS



Here's the Catalog you need! It's No. 4. Write Today It tells the story of Pyle-O-Lytes and Steam Turbo-Generators. Brighter Floodlighting

The Pyle-National Company
1334-58 N. Kostner Avenue
Chicago

Canadian Representatives The Holden Company, Ltd. Montreal Toronto Winnipeg Vancouver

1891 — 1924

MORGAN
Construction Company

Worcester, Mass., U.S.A.

Designers and Builders of

Morgan Continuous Mills

for

Billets, Sheet Bars, Skelp, Merchant-Bars, Hot-Strip, Rods

also

Wire Drawing Machines
Producer Gas Machines
Straightening Machines
Isley Reversing Valves
Re-Heating Furnaces
Reducing Gear Units
Shears

Our Engineering Department

is prepared to solve successfully your problems in design or arrangement of plant and equipment from open hearth to finished product

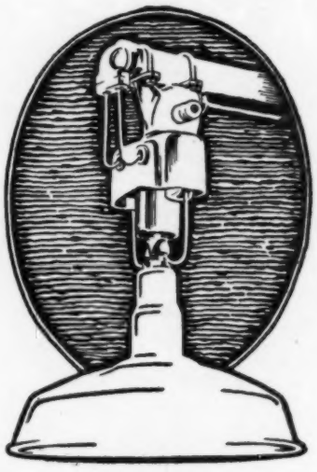
1891 — 1924

THOMPSON

Safety LOWERING Switch

or Disconnecting Hanger

"Teco" Underslung Model



makes

Lamp Maintenance

Accessible

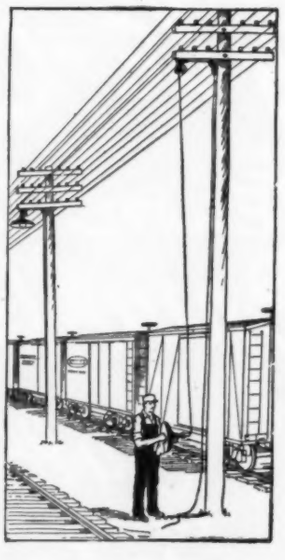
with

Ease and Safety

for both indoor and outdoor use—easily included in present lighting systems.

Get Catalog B-22

Safe



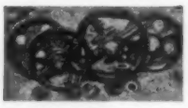
Logical

The Thompson Electric Co.

226 St. Clair Avenue, N. E.

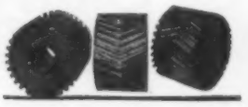
Cleveland, Ohio, U. S. A.

Herringbone Mill Pinions



Motor and Crane Gears

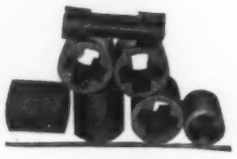
Mill Table Gears



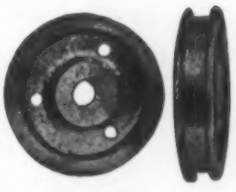
Herringbone Gears

Tool Steel Face
as hard here as on the very surface (This is one of the great differences between tool steel and case-hardening methods)
Toughened Center

Cincinnati "Tool Steel" gears outlast 8 to 10 Untreated and are much stronger



Coupling Boxes and Spindles



Crane Wheels

The Tool Steel Gear and Pinion Company
CINCINNATI, OHIO

MOLONEY
TRANSFORMERS

WE have been manufacturing transformers now for over a quarter of a century—a long time in an industry so young.

Moloney Engineering Experience has dealt with the transformer in every phase of its development.

From the first, Moloney Engineers have been animated by a two-fold purpose: to build the highest attainable quality, and to build it economically.

Moloney Transformers are recognized by all transformer users as the highest standard—a fact which demonstrates the success which has crowned the efforts of Moloney Engineers.

MOLONEY ELECTRIC CO.
Manufacturers of Transformers Exclusively
FACTORY AND MAIN OFFICE
St. Louis, Mo.
Offices in All Principal Cities

Built to Withstand Pile-Driver Blows

The construction of a "Union" Renewable Fuse is exceptionally rugged and rigid.

Its caps and washers are heavier than those in most fuses. Its ferrules are both screwed and riveted to the outside of the thick, tough, fire-resisting case. Only the highest grade materials are used throughout.

In addition, the force of a blowout is minimized in a "Union" by its heavier parts, by the link which blows without flash or violence and by safety valves at each end of large sizes. These features give it exceptional power of resistance.

The "Union" is the simplest as well as the strongest fuse in the market, easily and quickly taken apart and put together. Slipping in a new link after a blowout is almost as easy as to put in an entire new fuse.

"Union" Fuses are built to LAST. They withstand more blowouts than any other make. Consequently

The "Union" saves more than ANY other renewable fuse.

Of course they have the Underwriters' highest approval —that goes without saying.

Our new catalog contains many pages of Facts on Fuses. You will be interested in it. Send for a copy.

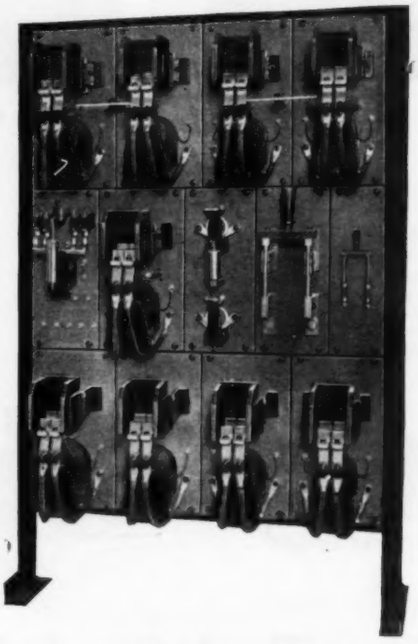
"UNION" RENEWABLE FUSES

CHICAGO FUSE MFG. CO.

Manufacturers also of Switch and Outlet Boxes, Cut-out Bases, Fuse Plugs, Fuse Wire and Automobile Fuses.

Chicago **New York**

REG. U.S. PAT. OFF. UNION



150 H.P. Type 4750 Full Speed Reversing Mill Controller

Automatic Motor Starters and Controllers

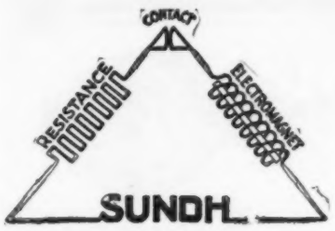
for

Alternating and Direct Current Electric Motors

May we send our nearest representative to see you?

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.

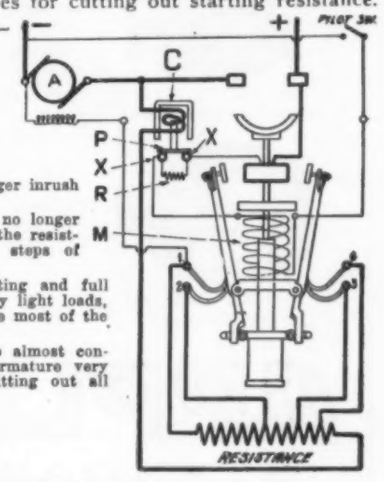


Steel Men!

Isn't this what some of you wanted, as brought out in your discussion of control in your Journal of November, 1921? A control that would have definite time limit modified with current limiting element?

You want a starter to obey its real function, don't you? i. e., to start and accelerate a motor by cutting in resistance, then out, in the shortest possible time in relation to the load. You want the motor to "mote" if it's at all possible to do so, whether the voltage is high or low, or whether there is excessive friction on a cold Monday morning. If the first current inrush does not start it, the next one may. If we can't get it to start on small amounts of current, we want to provide automatic means of increasing the current or power so that it will start, provided that no one has placed a crowbar in between the gears or there happens to be a short circuit. In that case, overload circuit opening devices take care of the condition.

We have been using this method since 1911. On large size motor starters, reversing and non-reversing, we use the multiple level starter as a pilot relay whose multi-contact energizes large shunt wound switches for cutting out starting resistance.



The action of this control is easily understood from the diagram, and the following description of operation:

The relay C is in series with the armature only during the starting period and is normally set to operate at about 130% of normal current. When the current in the armature of the motor equals or exceeds this setting on the starting inrushes, the armature of the relay lifts the plate P from the two contacts XX and by this action inserts the resistance R in series with the solenoid coil M of the automatic starter. The resistance R can be made to have a resistance so that when inserted in the circuit of the coil M (by action of excess load on the armature of motor at start) it partly destroys the effective magnetic pull of coil M and prevents the cutting out of any more resistance in the armature circuit, but at the same time there is sufficient magnetic pull to lift the core very slowly so that in time, even with the insertion of this resistance in the magnet coil circuit, the next succeeding step of resistance will be cut out, giving a larger inrush current to the motor.

Under normal conditions as soon as the current in the armature reduces to about normal, the coil C can no longer hold up plate P and it consequently drops, thus closing the circuit across contacts XX, and short circuiting the resistance R, allowing coil M to be again fully energized and to act with full power, thus cutting out succeeding steps of resistance quickly.

The retarding action caused by excess load on coil M may take place during any interval between starting and full running position. The time of the dash pot is generally set for a minimum of 1½ seconds, which in case of very light loads, the cutting out of resistance would take approximately this time, since the series relay coil C plate XX, would be most of the time short circuiting the resistance R.

Under abnormal, extremely heavy loads, where the series coil C would lift its armature and hold it up almost continuously, thus inserting all the resistance in the coil, R circuit on automatic starter coil M would lift its armature very slowly against the action of the dash pot and light pulling force, and may take up to 15 seconds before cutting out all resistance.

The resistance R may be made of a value as to either increase or decrease the pull of magnet coil M.

Write for Catalog.

SUNDH ELECTRIC COMPANY Newark, N. J., U. S. A.

ELECTRIC RUMSEY EQUIPMENT

ESTABLISHED 1895

RUMSEY ELECTRIC COMPANY

ELECTRIC SUPPLIES and MACHINERY

1007 Arch St., PHILADELPHIA

FACTORY DIRECT REPRESENTATIVES

EFFICIENT
RELIABLE
SERVICE

HIGH TENSION
ELPECO — ELECTRIC POWER EQUIPMENT CORPORATION — PHILADELPHIA, PA.
EQUIPMENT

LAPP
HIGH VOLTAGE
INSULATORS

PITTSBURGH

TRANSFORMERS

STORE AND OFFICE BUILDING
WAREHOUSE, 1010 CHERRY ST.

SANGAMO

METERS
BUILT LIKE A WATCH

"Sirocco"

AMERICAN BLOWER CO.
VENTILATING FANS
AND BLOWERS

C-H
CUTLER-HAMMER
CONTROLLING
DEVICES

UNITED STATES
ELECTRIC TOOLS

The Formia MAZDA

Type "SEC" Unilet with Appleton No. 2886 Receptacle

Type "GEC" Unilet with Round Base Snap Switch

Type "SE" Unilet with Pony Receptacle

Let Unilets Save for You!

UNILETS will save for you as they have saved for many other contractors and owners—in time, labor, material and trouble. Why? Because they are correctly designed, light in weight, strong, easily handled and installed—large wiring spaces and no rough edges to cut wires—making a neat, easy and quick wiring job at lowest cost.

Remember the name Unilets and the reputation of the maker. Profit by their use in your work.

Our Catalog 9-T contains a fitting for every purpose. Write for it.

APPLETON ELECTRIC COMPANY
General Offices and Factory:
1717 Wellington Avenue - Chicago

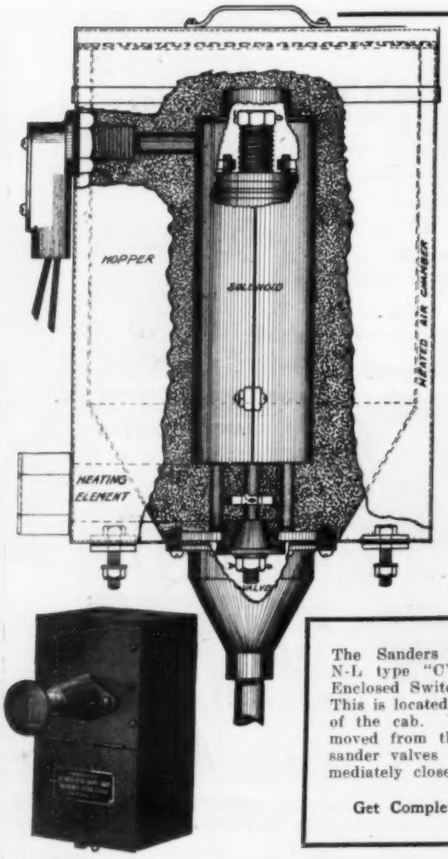
Type "WDC" Unilet with 3-wire Porcelain Cover

Type "FS" Unilet, 2-gang with Cover for Toggle Switches

Type "T" Unilet with "Unitap" Connection Block

APPLETON UNILETS

STANDARD FOR BETTER WIRING



Quick, Positive, Accurate Sanding of Crane Tracks means Safety

This hopper is easy to install. Well-made and durable. Weatherproof in design. Size over all 12" x 12" x 17". Has a warm air chamber kept heated by a heating element. This feature is to keep sand in proper condition so that it responds quickly and easily. Sands the track accurately and effectively.

N-L

The Sanders are operated by an N-L type "C" Momentary Contact Enclosed Switch (by hand or foot). This is located in the operating cage of the cab. When pressure is removed from the switch button, the sander valves automatically and immediately close.

Get Complete Details at Once

You can economically do it with

THE LINTERN ELECTRO MAGNETIC SANDER

The old hand method of sanding is dangerous and costly. By means of this modern sander you sand your tracks on the instant and actually prevent skidding, wheel spinning and those strains to crane and runways that mean expense. Now you can bring safety into sanding in its highest degree. You can keep your cranes in continuous operation. You won't even consider the cost when you realize the results.

THE NICHOLS-LINTERN COMPANY
7960 Lorain Avenue, Cleveland, Ohio

Sales Representatives:

Pharo Engineering Co. - - - - - 517 Park Bldg., Pittsburgh, Pa.
F. F. Bodler - - - - 903 Monadnock Bldg., San Francisco, Cal.
A. C. Burleigh - - - - - - - - Little Bldg., Boston, Mass.
Gus. W. Wagner - - - - 1011 Majestic Bldg., Detroit, Mich.

Canadian Representative:

Railway & Power Eng. Corp., Ltd., 133 Eastern Ave., Toronto, Ont.

Steinbart Patent Pressure Burners

offer an investment of 200% and better to every blast furnace or steel works. If you want to know more about them ask any of our customers.

Steinbart Burners are in operation or under construction at the following plants:

National Tube Company	Lorain, Ohio	All Stoves
" " "	" "	6—1300-hp. Boilers
" " "	McKeesport, Pa.	7 Stoves
" " "	Wheeling, W. Va.	Boilers
Wheeling Steel Corp.	Steubenville, Ohio—1st order	4 Boilers
" " "	" " 2nd "	7 "
" " "	" " 3rd "	1 Boiler
" " "	" " 3rd "	8 Stoves
Bethlehem Steel Company	1st order—Sparrows Point, Md.	2 Boilers
" " "	2nd " Lackawanna, N. Y.	2 "
" " "	3rd " " "	8 "
" " "	4th " Johnstown, Pa.	4 Stoves
Trumbull-Cliffs Furnace Company	Warren, Ohio—1st order	4 Boilers
" " " "	" " 2nd "	3 Stoves
Shenango Furnace Company	Sharpsville, Pa.—1st order	4 "
" " "	" " 2nd "	4 "
Otis Steel Company	Cleveland, Ohio	4 "
Steel Company of Canada	Hamilton, Canada	6 Boilers
Struthers Furnace Company	Struthers, Ohio	5 Stoves
Youngstown Sheet & Tube Company	Indiana Harbor, Ind.	3 "

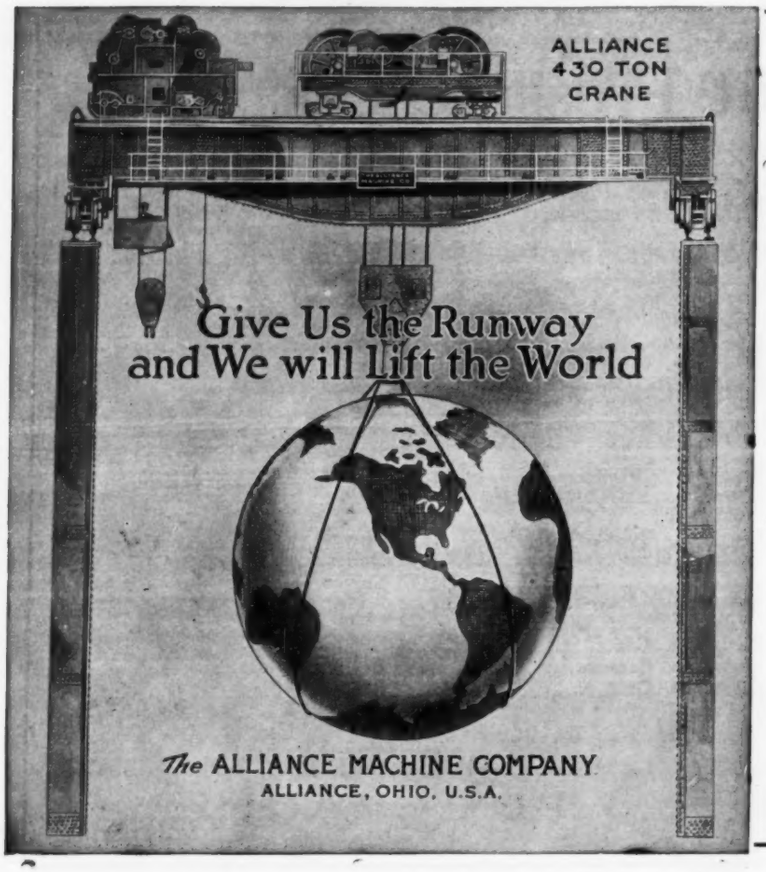
For particulars apply to the American Heat Economy Bureau, Inc., 926 Wabash Building, Pittsburgh, Pa.

For Plant Haulage and Switching

Plant managers are beginning to realize the unquestioned fact that the steam dinky is antiquated and expensive. Many of them find large Irontons less costly and more dependable for switching, while small Irontons save money for hauling on narrow gauge track inside the plant yards. Both work 24 hours a day when desired.

Let Ironton Engineers survey your conditions and make a report.

The
IRONTON
Engine Co.
Ironton, Ohio



ALLIANCE CRANES

Largest Builders of the World's Largest Cranes

204 of 100 Tons Capacity and Over

STANDARD CRANES

55	100	tons
2	115	tons
42	125	tons
24	150	tons
22	175	tons
2	200	tons
1	225	tons
1	250	tons
3	430	tons

STRIPPING CRANES

8	100	tons
1	125	tons
19	150	tons
13	200	tons
1	Single Ram, 320	tons

COMBINATION CHARGERS AND STRIPPERS

3	100	tons
3	150	tons
4	200	tons

Pittsburgh Transformer Company

Largest Manufacturers of Transformers Exclusively in the United States

Pittsburgh, Pennsylvania

for Series Motors Grade C

stands up under the severe conditions encountered with reversing crane and mill motors.

CORLISS CARBON CO.
BRADFORD, PA.

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LAPP HIGH VOLTAGE PORCELAIN

Did you ever hear of a failure of a Lapp Insulator?

Seven years of production—including highest voltage pin and suspension types —without a failure!

There is the reason for use of Lapp Insulators, besides which—for "trimmings" —they provide unexcelled mechanical strength.

Lapp vacuum process of porcelain production, surfaces of porcelain glazed all over, Lapp over potential test methods.

Lapp Insulators Do Not Fail?

LAPP INSULATOR CO., Inc., LeRoy, N. Y.

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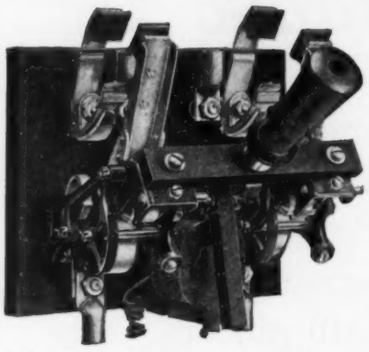
Good Motor and Control Insurance

is what you get when you install

Roller-Smith

INDUSTRIAL TYPE

Circuit Breakers



100 ampere, 220 volt, two pole rigid arm, combined overload and under-voltage, "Industrial" Type Circuit Breaker.

When there is a short, you can depend upon Roller-Smith circuit breakers to "get on the job." When they *should* open they *will* open. They are dependable. They assure you of the highest degree of protection. They insure your motors and electrical equipment against serious damage.

Because of their simplicity, ruggedness, speed, accuracy and reliability, Roller-Smith Industrial Type Circuit Breakers are a splendid investment for any Company that wants the highest degree of protection and is willing to pay a reasonable amount for it.

Bulletin AK-520 will be mailed upon request.

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Electrical Instruments, Meters and Circuit Breakers

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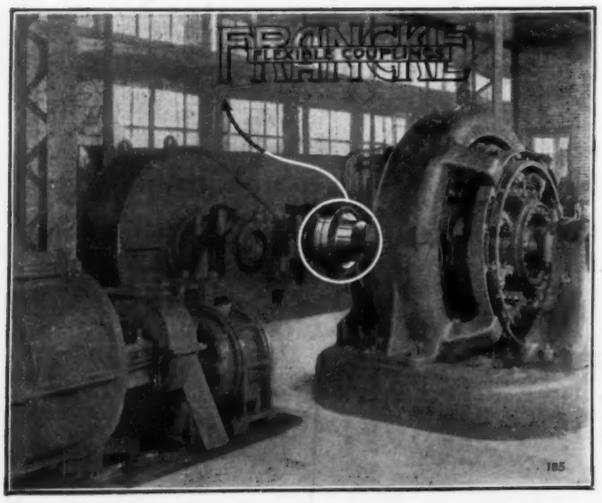
Flexible Couplings for every service



5 Types of Francke Flexible Couplings.

Pressed Steel Type—for Fractional H.P. drives.
Heavy Pattern Type—a general purpose coupling.
High Speed Type—for high speed drives.
Double Type—for heavy duty, continuous drives.
Marine Type—used on small power boats.

FRANCKE
FLEXIBLE COUPLINGS

"They make good machines last longer"

In all Francke designs laminated steel springs provide for shaft misalignments in every direction. They cushion load shocks and vibrations. Where needed they also act as a safety device.

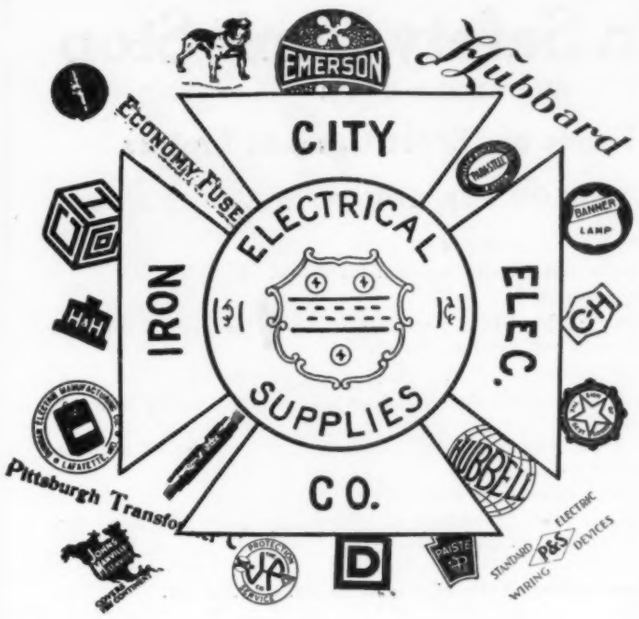
Ask for Bulletin No. 37.

SMITH & SERRELL

Coupling Specialists Since 1912.

64 Washington Street, Newark, N. J.

District Office, Fulton Building, Pittsburgh



The Trade Mark

of the

Iron City Electric Co.

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"The House That Service Built"

IS BACKED BY A GROUP OF

TRADE MARKS

of Well Known Manufacturers Guaranteeing the Quality of the Goods You Receive

Electrical Engineering and Manufacturing Company

General Offices:

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We are prepared to furnish your requirements in the following materials and equipment:

"MORGANITE" Carbon-Graphite Metal Brushes.

"ROWAN" Automatic Controllers and Starters.

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"AJAX" Resistance Type Welding and Bonding Machines.

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RAILWAY and Mine Bonds.

MINE HOISTS and Winches, Car Pullers, etc.

HIGH and **LOW** Tension Insulators.

"ELPECO" High and Low Tension Switching Equipment, Bus Fittings, etc.

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We have a corps of expert engineers, specialists in the above lines, who will be glad to give immediate attention to your inquiries or to see you at your request for consultation regarding applications or equipment. Call or write our nearest office.

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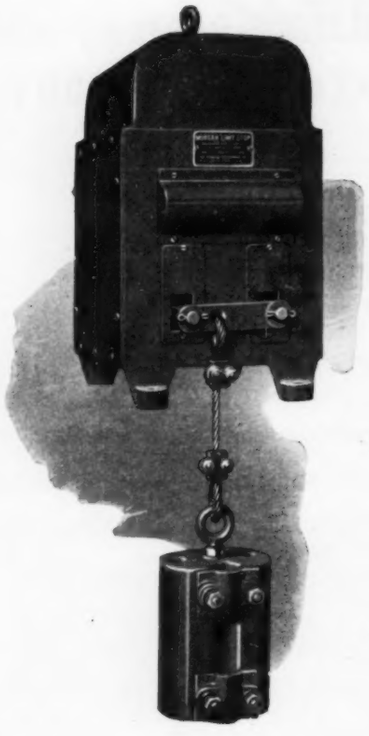

Morgan Safety Limit Stop

WACKERLY TYPE

For All Types of Direct Current Motors

A FEW OF THE ADVANTAGES

No heavy current broken by contactors.

Limit Stop can be connected up with any standard make of controller.

No extra conductors required.

Normal lowering circuits established immediately upon reversal of controller. No waiting to lower through resistance.

No external banks of resistance. Limit Stop is self contained.

Only one swinging weight used, this being guided by one of the hoisting ropes.

Positive in action. A movement upward of weight of a fraction of an inch will actuate limit stop.

Occupies minimum floor space on trolley.

Sequence of operation of contactors obtained by simple system of levers. No cams, springs or counterweights used.

For full particulars on this stop send for Bulletin No. 29.

The Morgan Engineering Co.

Alliance, Ohio

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122 So. Michigan Ave.

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120 Broadway

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1420 Oliver Bldg.

W. E. FINISH SALAMANDER

magnet wire is particularly adapted for rewinding field and armature coils, solenoids, etc., and is used extensively in the steel industry. It is acid-proof, moisture-proof, oil-proof, heat-resisting and has an extremely tough, smooth, hard finish.

For further information write to our nearest representative for Salamander wires and cables—

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of General Electric Company

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BRUSHES

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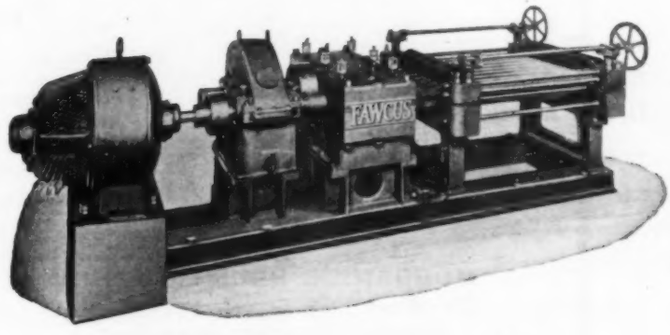

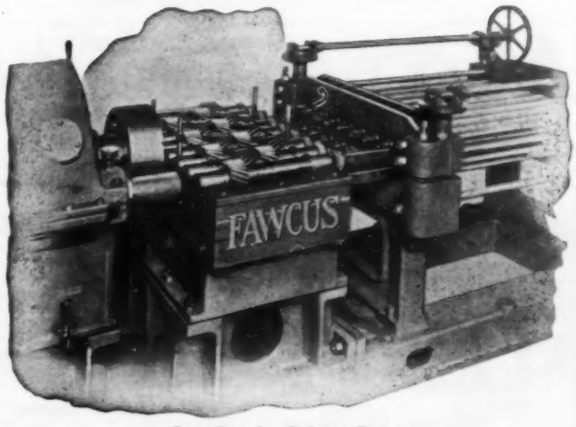

Gear Box for Driving Rollers

FAWCUS
Sheet Roller Leveler

Designed for the production of an improved product in cold rolling sheets. The use of Fawcus Herringbone Gears throughout eliminates all vibration and gives a steady uniform velocity to the rolls, overcoming the marking of sheets, and producing a perfect sheet without buckles, waves or riffles.

The same type of leveler has been devolped for strip mill product with shorter rolls and lighter construction, but of the same general design. This machine can be built with the entering rolls adjustable also, while in the machine illustrated the last roll only has independent adjustment.

FAWCUS MACHINE CO.

PITTSBURGH, PA.

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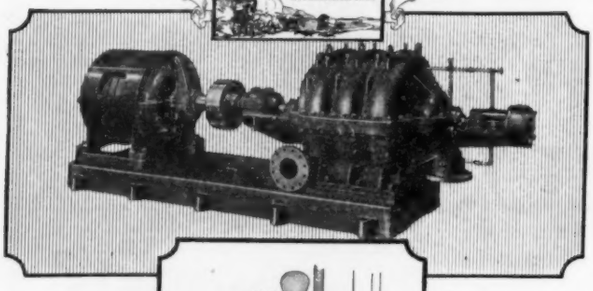
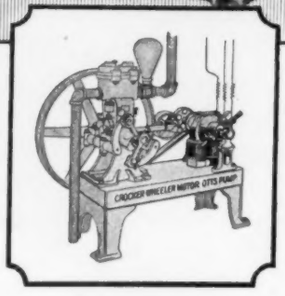
CROCKER-WHEELER

PIONEER MOTOR MANUFACTURERS
Established 1888





Above—A modern motor-driven pump—direct-connected to 200 H. P. Crocker-Wheeler Induction Motor.

Left—The first motor-driven pump—Otis Pump of 1890, belt connected to Crocker-Wheeler Bipolar Motor.

34 Years Ago—and Today

The first motor-driven pump and today's —both Crocker-Wheeler driven

Down in the black depths of the mine, amidst the mud and silt of the reclamation job, in factory and power plant—in thousands of places—the modern motor-driven pump serves man in many ways.

Electric motor drive for pumps, with its high efficiency and other important advantages, is one of the many motor applications introduced and developed by the Crocker-Wheeler Company. The small insert above shows the original motor-driven pump—an old house type Otis Pump of 1890, driven by a Crocker-Wheeler Bipolar Motor.

36 years of incomparable experience are built into Crocker-Wheeler Motors and Generators of today. Made in A. C. and D. C. types, for all requirements.

CROCKER-WHEELER COMPANY
AMPERE NEW JERSEY

BALTIMORE	CHICAGO	NEW YORK
BIRMINGHAM	CLEVELAND	PHILADELPHIA
BOSTON	DETROIT	PITTSBURGH
BUFFALO	NEW HAVEN	SAN FRANCISCO

Foreign Distributor: International Western Electric Co.

CROCKER-WHEELER COMPANY TRADE MARK

MOTORS & GENERATORS

Mpundulu

The mpundulu is a spirit used by the kaffir to throw spells on other people.

Unless one is able to keep the head in some water the mpundulu cannot be seen.

Operators over here often see similar mpundulu when water doesn't even enter the consideration.

Anything that gets heavy on the nerves brings similar visions—such as the chattering of misapplied carbon brushes.

That's why we feel that we're doing a real humane work to pull off such brushes and prescribe the proper Morganite.

The silent hush of Morganite soothes the mind—replaces nerves with nerve.

MORGANITE BRUSH CO., INC.
519 West 38th St., New York City
DISTRICT ENGINEERS AND AGENTS

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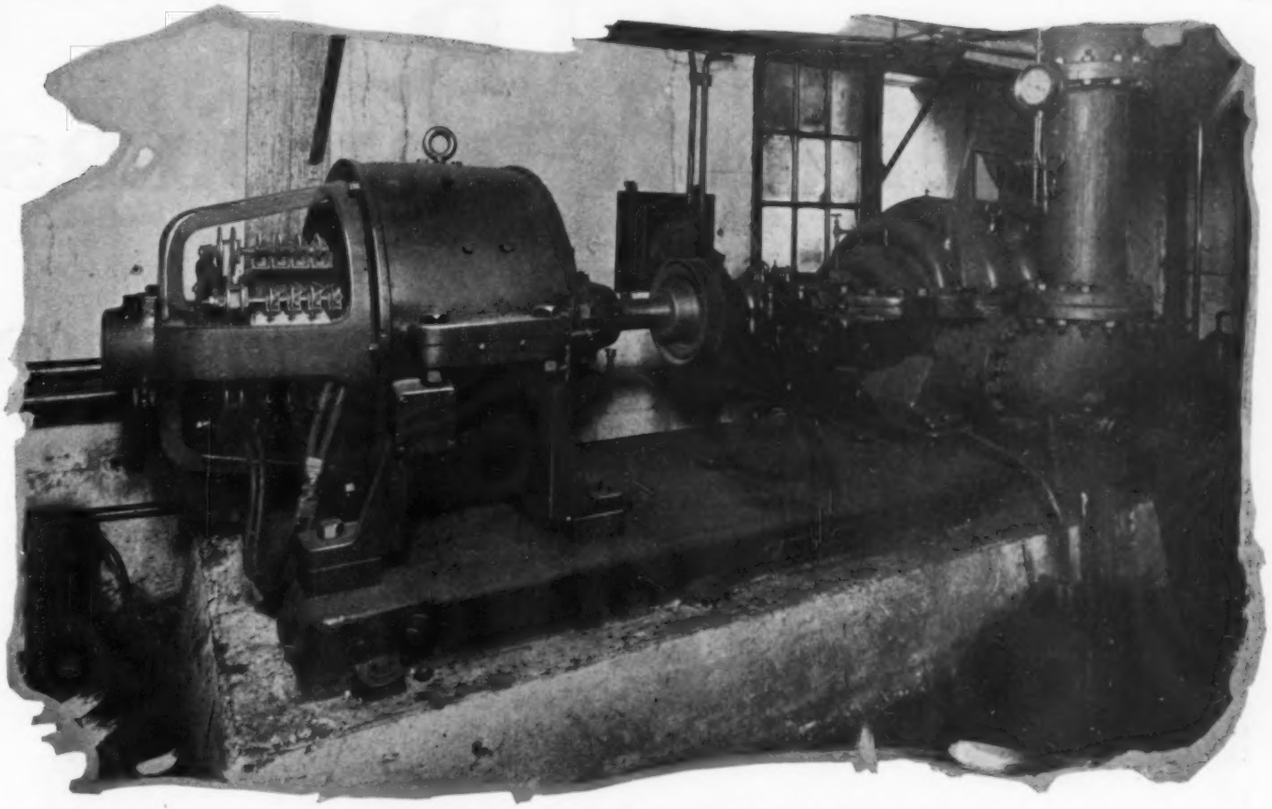
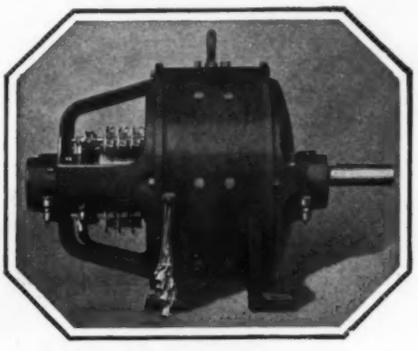


175 h.p., 675-900 r.p.m. Type T Reliance Motor driving Cameron Pump.



Every step in the design and manufacture of Type T motors is influenced by the needs of steel mill service. We know from intimate contact with steel mill work the great need for quality and strength in every motor part.

Ready to Go— 24 Hours a Day

You can rely upon Type T Reliance Motors for the dependable service which you expect on pumping units like this.

These motors are rugged mechanically and are carefully insulated to stand the strain of hard service under unfavorable conditions 24 hours a day. They have been doing it for over eight years.

We shall be glad to tell you where and how.

Bulletin 2014 shows in detail how Type T Motors are built to do more than meet ordinary demands.

RELIANCE ELECTRIC & ENGINEERING CO.
1080 Ivanhoe Road, Cleveland, O.

Branches: Boston, New York, Philadelphia, Pittsburgh, Cincinnati, Detroit, Chicago, Birmingham, Ala.

Type T Heavy Duty
RELIANCE MOTORS
Direct Current

AIR!

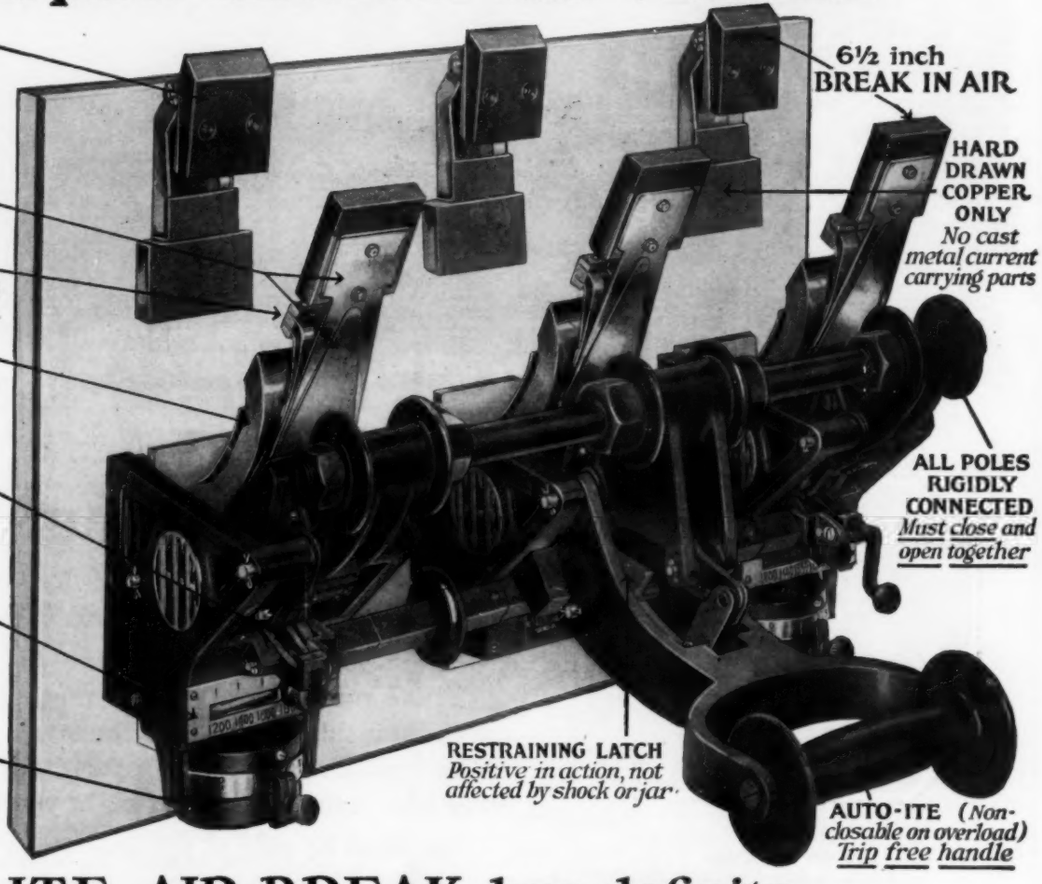
I-T-E CIRCUIT BREAKERS

For Alternating Current

600 VOLTS OR LESS

Give protection without complication

All parts accessible and VISIBLE


COPPER JACKETED PRESSURE CARBONS
For initial contact and final break
Mechanically strong
Electrically perfect
PHOSPHOR BRONZE CARBON SUPPORTS
HEAVY METALLIC SECONDARY BREAKING CONTACTS
LAMINATED BRIDGE
Each leaf individually formed - Heavy even pressure on every Lamination
CLOSING TOGGLES
Afford heavy contact pressure with easy closing
OVERLOAD
Direct acting. Long scale calibration. No relays or series transformers
DALITE
(Direct acting time limit) feature. Adjustable from zero to maximum time. No relays
6½ inch BREAK IN AIR
HARD DRAWN COPPER ONLY
No cast metal current carrying parts
ALL POLES RIGIDLY CONNECTED
Must close and open together
RESTRAINING LATCH
Positive in action, not affected by shock or jar
AUTO-ITE (Non-closable on overload)
Trip free handle

I-T-E AIR BREAK has definite advantages not present in the oil breaker

1. *No oil — to leak, carbonize, burn or explode — Just air.*
2. *No tanks to conceal anything — or the lack of it.*
3. *No cells — nothing which needs or deserves to be imprisoned — Just a faithful and efficient servant.*
4. *Inherent simplicity — with resulting low cost of installation and maintenance.*

The I-T-E CUTTER COMPANY
ESTABLISHED 1888 PHILADELPHIA

The New Inductive Time-Limit Controller

This new type of steel mill controller with its uniform accelerating period insures better production because of the functioning of the auxiliary machines on a definite time schedule.

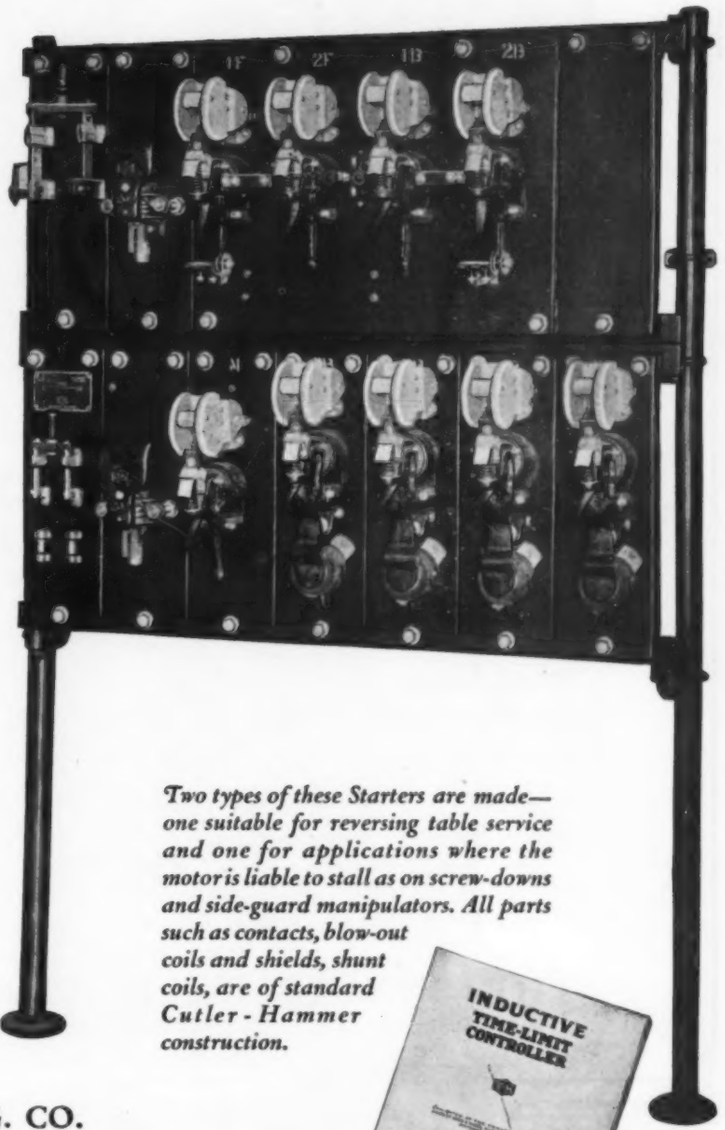
Their cycle of operation can then be made to dovetail with the main mill production program.

This is accomplished through the development of the inductive time-limit principle of acceleration which eliminates the usual dash pots, relays, inter-locks or other moving parts.

The entire construction and all parts are extremely simple — adjustments for the timing are readily made in the stationary parts.

In brief—"time limit" acceleration, favored by steel mill engineers, is obtained in this new C-H Starter without any of the features that have been considered unsatisfactory for strenuous steel mill service.

Publication C-2 will be mailed on request.

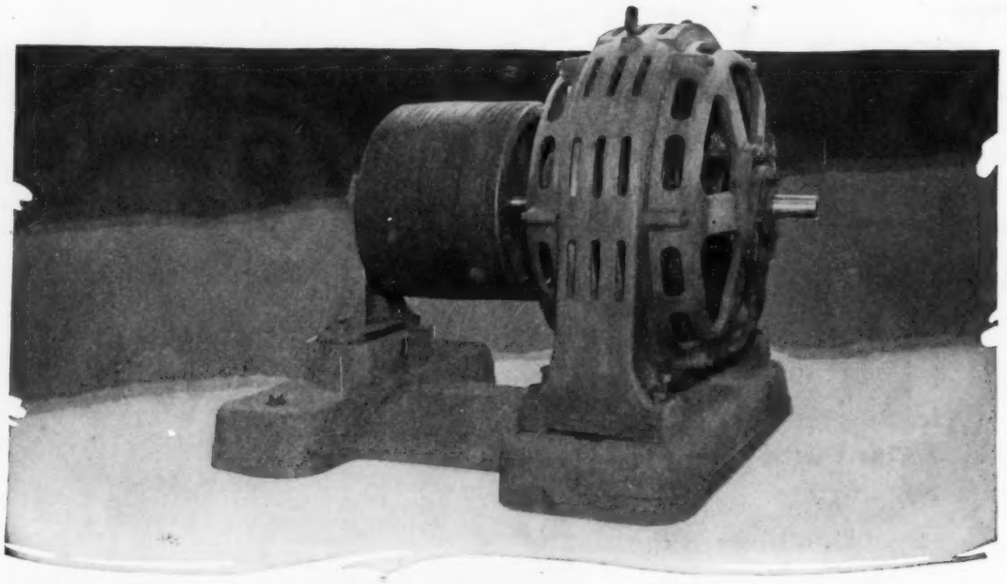


Two types of these Starters are made—one suitable for reversing table service and one for applications where the motor is liable to stall as on screw-downs and side-guard manipulators. All parts such as contacts, blow-out coils and shields, shunt coils, are of standard Cutler-Hammer construction.

THE CUTLER-HAMMER MFG. CO.
Motor Control Department
Works: MILWAUKEE *and* NEW YORK
Offices and Agents in Principal Cities
Northern Elec. Co., Ltd., Canada

CUTLER-HAMMER

SKF



Full-Time Production—Low Cost
Operation With Ball Bearing Motors

THERE'S no danger of serious interruptions in production schedules due to troubles arising from bearing wear on this 300 H. P. motor. It's safeguarded from such possibilities by the three Skayef Self-Aligning Ball Bearings on the armature shaft.

They insure indefinite operation and material reductions in maintenance expense. Chrome alloy steel balls rolling in hardened races of steel show little wear after years of running, thereby preventing burnouts due to rotor striking the stator and eliminate bearing adjustments. Oil cannot leak on windings.

THE SKAYEF BALL BEARING COMPANY

1279 Supervised by SKF INDUSTRIES, INC., 165 Broadway, New York City

"Two Minutes for Lubrication Instead of Two Hours"

"MINUTES lost were dollars wasted when our men went from one bearing to the other, lubricating each one individually.

"Such waste did not end here," continued this executive, "for it is not surprising that bearings difficult of access, hazardous to reach, should be neglected. Friction, wear, faulty operation and eventual breakdown of moving parts inevitably resulted."

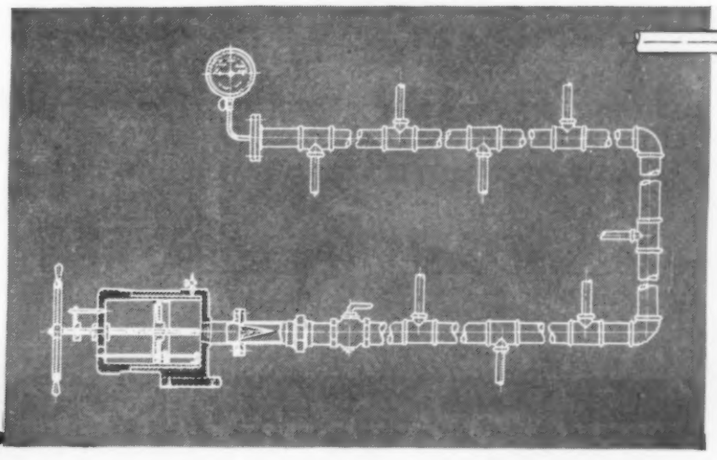
Yet it was preventable.

With the Keystone Manifold Safety System of Keystone Grease Lubrication "metal arms" reach from the Keystone Manifold Safety Lubricator to the inaccessible, dangerous-to-reach bearings all over a machine. Thru these feed lines, Keystone Grease is forced under high pressure, directly to the bearings, without waste.

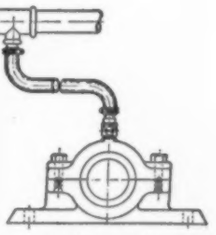
No other lubricating system, except the Keystone, frees the workman from individual attention to each and every bearing. No other lubricating system, except Keystone, has centralized control, making possible the lubrication of many bearings, from one convenient, safe, central place. It is an exclusive Keystone feature. KEYSTONE LUBRICATING CO., *21st & Clearfield Streets,* PHILADELPHIA, PA. *Est. 1884.*

Cross sectional view of Keystone Pressure Reduction Valve

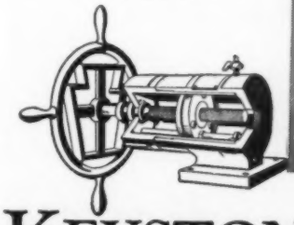
Installation suggestion showing Manifold Safety Lubricator. "Header" Line, "Take-Offs" and Special Grease Gauge



Illustrating "Take-Off" from "Header" Line to bearing



Sectional view of Keystone Manifold Safety Lubricator, which is the main grease reservoir and agency of compression



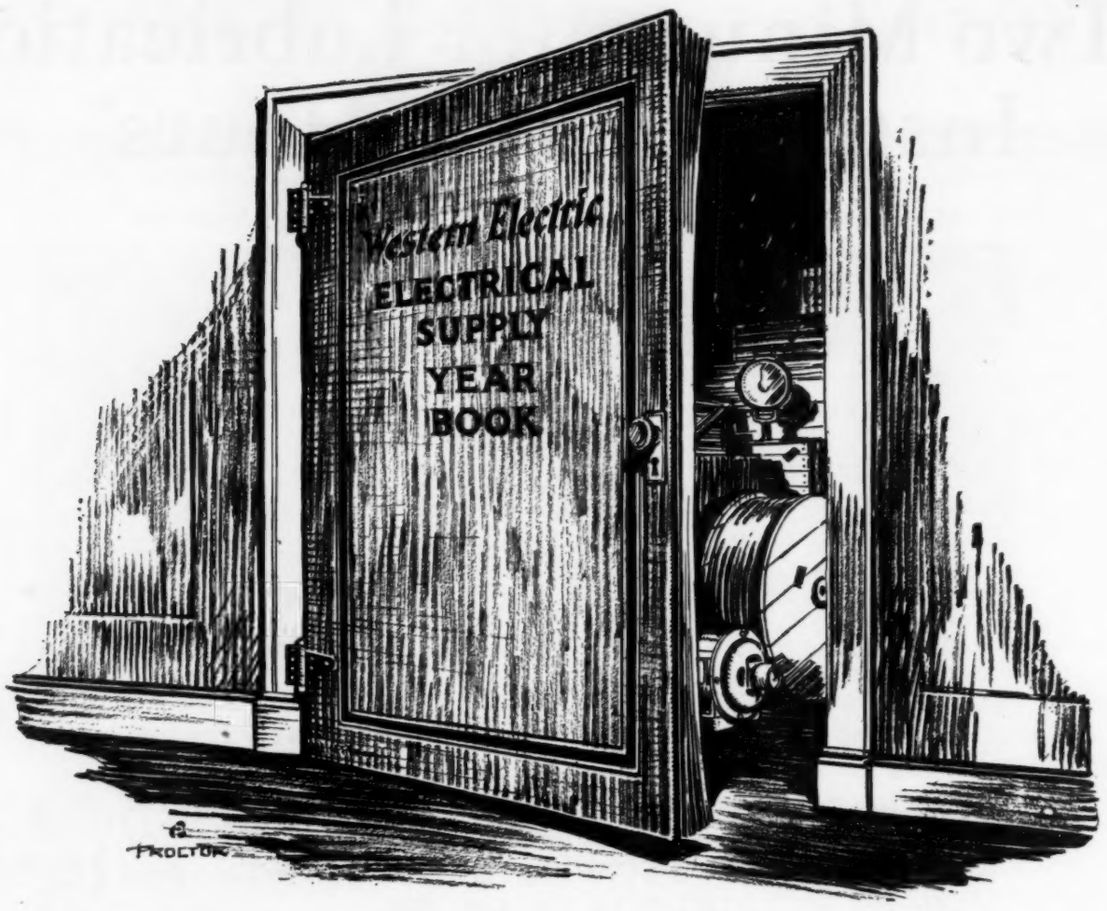
KEYSTONE MANIFOLD SAFETY SYSTEM *of* KEYSTONE GREASE LUBRICATION

(Fill in—tear out—and mail)

KEYSTONE LUBRICATING CO.
Philadelphia, Pa.

Gentlemen: Send along your booklet, "Send Him Back to Them—Safe," containing a plain talk by a master mechanic about your system. My name, company name and address I have written below in the margin of the magazine.

KEYSTONE GREASE
The Master Lubricant



The door to your biggest motor stock room

Open the Western Electric Year Book and you have access to over 60,000 electrical items, any of which are procurable through our nearby Distributing House.

This Distributing House is stocked with Western Electric Motors and Control that are skillfully designed and ruggedly constructed.

Look upon this Distributing House as your own stock-room, ready for your regular or emergency orders. You can depend on it, as Western Electric delivery is prompt and Western Electric quality is dependable.

For further particulars write our nearest Distributing House or the Western Electric Company, 100 East 42nd Street, New York City.

Western Electric

Pittsburgh Youngstown New York
Cleveland Chicago Buffalo

For Unusual Lighting in Industry

use Benjamin Elliptical Angle Reflectors

Wherever overhead structures make center suspension difficult and wherever lighting from the side is desired to supplement illumination from overhead.

Benjamin Elliptical Angle Reflectors distribute the light not only to the front but to the sides in such a manner as to build up illumination between the units.

Highly advantageous for illuminating either vertical or horizontal surfaces or a combination of both.

Our nearest office will be glad to supply further information regarding these unusual reflectors.

BENJAMIN ELECTRIC MFG. CO.

120-128 S. Sangamon St., Chicago

247 W. 17th Street, New York

448 Bryant Street, San Francisco

Know the true condition of your batteries

SO much reliance must be placed on the proper performance of your storage batteries that it is shortsighted to take any chances on their condition or in their charging.

Voltage and specific gravity readings require correction for many factors and are so inconvenient to take that the batteries often remain unchecked for long periods.

The amperehour meter eliminates any uncertainty about the condition of your batteries, giving a true indication of the state of charge or discharge at all times.

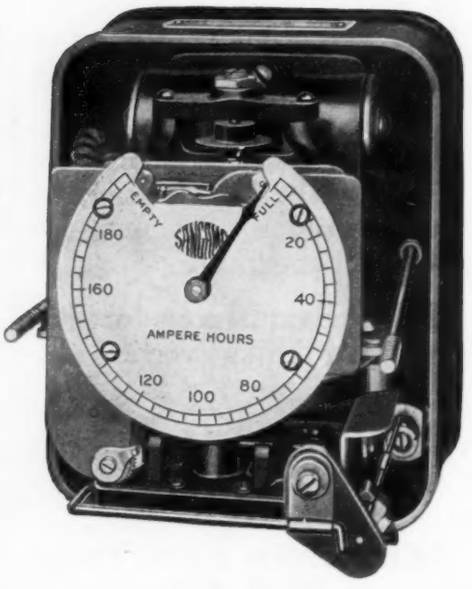
A contact at the full-charge point will automatically terminate the charge at the proper time. Another contact, if desired, can be furnished to change the charging rate automatically at the gassing point.

An adjustable resistor element, embodied within the meter, causes it to run slower on charge than on discharge, thus giving the battery the necessary excess charge.

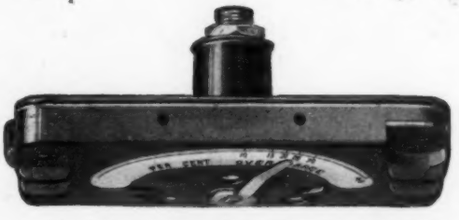
Place the charging of your batteries upon a reliable, automatic basis and know their true condition at all times. It means battery dependability and added battery life.

The Sangamo Type N Amperehour Meter will do all this for you at a small cost. It is the simplest form of the simplest type of meter — operating on the mercury-motor principal.

Investigate the merits of this sturdy meter of remarkably high sustained accuracy. It is described in Bulletin 68. Write for a copy.



Sangamo Type NF Amperehour Meter for switchboard service, cover removed.



Variable resistor element by means of which the desired degree of over-charge is automatically given the battery.

Sangamo Electric Company

Springfield, Illinois

New York Chicago Birmingham San Francisco Los Angeles

SANGAMO METERS

FOR EVERY ELECTRICAL NEED

7020-3

Strom Ball Bearings increase efficiency of many types of electric motors

Modern electric motors are now equipped with ball bearings. Many of them with Strom Ball Bearings. For experience has taught engineers the superior qualities of these fine bearings.

Many reasons are quoted in support of the superiority of ball bearings for this purpose. Five outstanding advantages are:

1—A permanent and uniform air gap between armature and coils.

2—Oil leakage is eliminated, reducing insulation troubles.

3—Starting and running resistance reduced and equalized.

4—More compact motor design because of small bearing space required

5—End motion and vibration reduced to a minimum.

Added to this are greatly reduced costs of maintenance and service.

For additional information, catalogs, price lists, load capacities at various R.P.M., write to us. Our experts will gladly assist you in determining the best type and size of bearing for your needs. Strom Ball Bearings are interchangeable with other standard makes.

Double-acting thrust bearing, flat seats (grooved races) 2100-F Series

Single-acting thrust bearing, flat seats (grooved races) 1100-F Series

Single-acting, self-aligning thrust bearing 1100 Series

Single-acting, self-aligning thrust bearing, leveling washer. 1100-U Series

Double-acting, self-aligning thrust bearing, leveling washers 2100-U Series

Single-row deep-groove Standard type, radial bearing

Double-row, deep-groove Standard type, radial bearing

Angular contact bearing, combination radial and thrust

Double-row, maximum type, radial bearing

Single-row, maximum type, radial bearing

Strom BALL BEARINGS

STROM BALL BEARING MFG. CO.

Formerly U. S. Ball Bearing Mfg. Co.

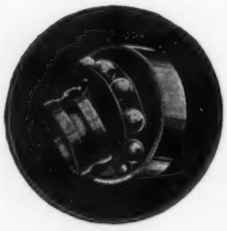
4594 Palmer Street, Chicago, Ill.

PRECISION

"NORMA"

PRECISION BALL BEARINGS

For High-Speed, High-Duty Performance



OPEN (SEPARABLE) TYPE

Where the utmost serviceability must be had under long-continued operation at high speeds—there is the recognized place of **"Norma"** Precision Bearings in the machinery world. Proved by the tests of time and service, they have been progressively bettered to meet ever harder conditions—rather than cheapened to meet low-price competition. They are daily demonstrating their superlative dependability in hundreds and hundreds of thousands of high-speed, high-duty machines where the failure of a bearing would mean losses a thousand times the cost of the original bearing equipment.

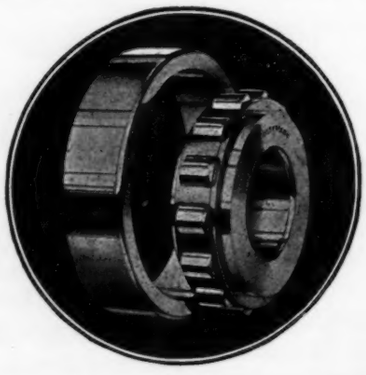
CLOSED (NON-SEPARABLE) TYPE

"HOFFMANN"

PRECISION ROLLER BEARINGS

For Heavy Loads and Hard Service

Speed qualities equal to those of the best ball bearing, combined with a steady load capacity far beyond that of any ball bearing and a temporary overload capacity which no ball bearing has—these distinctive features suggest the field for **"Hoffmann"** Precision Roller Bearings in the mechanical industries.



Where the duty is hardest and the operating conditions most difficult and the necessity for stand-up-ability the greatest—there do **"Hoffmann"** Roller Bearings reveal their true value and return the dividends which justify their use. Made in standard and self-aligning types, for all speeds and powers.

Exhibited at Booths 234-5, National Exposition of Power and Mechanical Engineering, New York, December 1-6, 1924

NORMA-HOFFMANN BEARINGS CORPORATION

Anable Avenue Long Island City New York

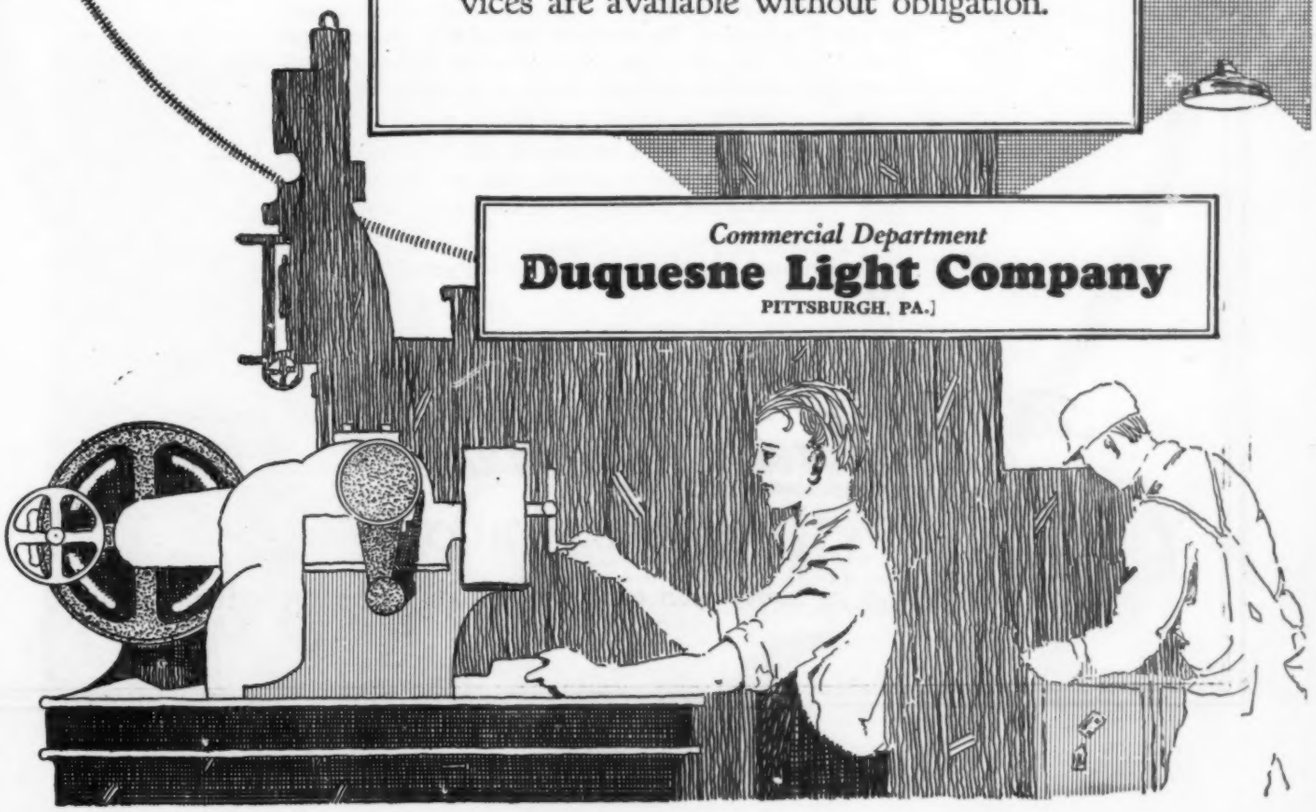
PRECISION BALL, ROLLER AND THRUST BEARINGS

BEARINGS

Consider the EYES

IN the industrial plant keen eyesight is necessary to produce efficient work, eliminate errors and avoid accidents. To surround the workman with proper lighting is to increase his efficiency. In this age of increasing costs, greater accuracy is necessary in production.

Our Illuminating Engineer can undoubtedly suggest many ways in which your lighting can be bettered. His services are available without obligation.



Commercial Department

Duquesne Light Company

PITTSBURGH, PA.

THREE WEEKS

Just three weeks from the day the order was released to our Production Department the above photograph was taken (at that the photographer had to chase down the tracks about half-a-mile to overtake the car).

These 1000 KV-A 22000 Volt Single Phase Packard transformers were sold to the U. G. I. Contracting Company for installation on the lines of the Northern New York Utilities Company at Croghan, New York.

If you are interested in exceptional service as well as exceptional transformers ask for a Packard proposition.

The Packard Electric Company

WARREN, OHIO

Packard is never seen except on goods of honest value.

PROTECTION

FOR YOUR WORKERS

TURN
First to the left
Then to the right
Turn the handle
—and U-Re-Lite!

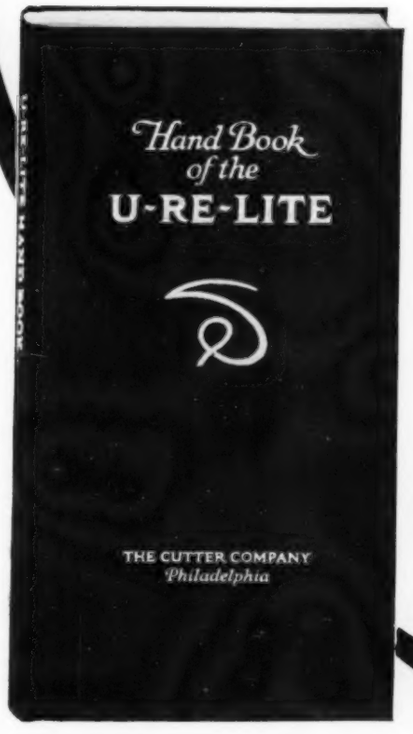
Inadequate protection against overloads and short circuits causes some of the most fearful industrial accidents. Employees' insurance is a splendid thing, but it will not restore the dead, nor will it adequately compensate the man maimed for life. Every establishment using electrical equipment should give its employees and equipment the best protection obtainable.

U-RE-LITE

"The I-T-E Circuit Breaker in the Steel Box"

is your logical choice because of its demonstrated ability to rupture the heaviest overloads and short circuits, and the assurance which its construction affords against inadvertent contact of the operator with live parts. When a "short" or overload occurs, it is not necessary for the workman to call an electrician; he simply, with two twists of the wrist, in perfect safety, resets the U-RE-LITE and restores service instantly.

First to the left, then to the right,
Turn the handle, and U-RE-LITE!



Write for 96-Page Illustrated Catalog — HAND BOOK OF THE U-RE-LITE. Sent free upon request.

The CUTTER COMPANY
ESTABLISHED 1888 (I-T-E) PHILADELPHIA

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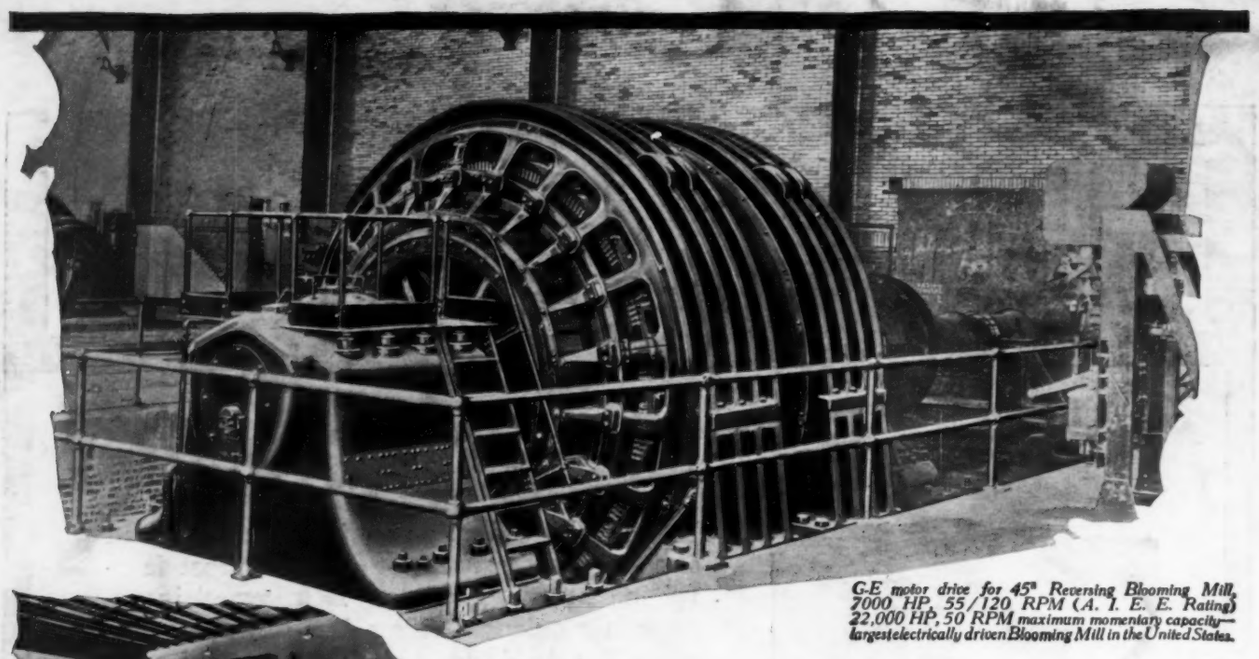
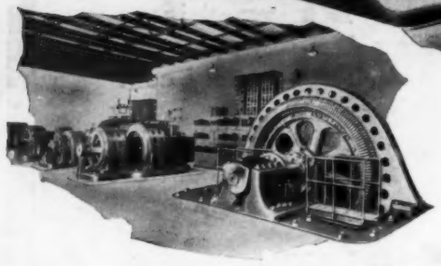
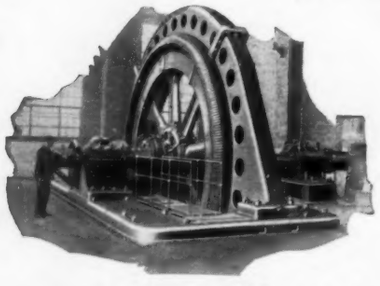


G-E motor drive for 45" Reversing Blooming Mill, 7000 HP, 55/120 RPM (A. I. E. E. Rating) 22,000 HP, 50 RPM maximum momentary capacity—largest electrically driven Blooming Mill in the United States.



G-E adjustable speed motor rated 1800/1500/1200 HP, 240/200/160RPM—driving finishing stands in 10" Hoop Mill.



G-E motor—2500 HP, 82 RPM, 6600 Volt—with breakable end thrust driving Roughing Rolls in Structural Mill.

G-E motors—true as steel

IN the leading steel mills operating main rolls with G-E motors and control devices, costs reduced through increased tonnage—lower maintenance charges—quality improved through better control, are actual performance records which show the advantages of installing G-E equipment.

The requirements of main roll drives which are being successfully met by G-E motors and control are:

Constant Speed Mills for sheet and plate mills—driven by single speed motors, usually of induction type.

Adjustable Speed Mills for strip mills and merchant mills—driven by adjustable speed induction motors with either Scherbius or rotary converter control, or by direct current motors with Ward-Leonard or motor field control.

Reversing mills—driven by direct current motors with Ward-Leonard control, or with combination of Ward-Leonard and motor field control.

The choice of the particular type of drive for any steel mill can best be determined after consideration of the factors affecting the problem by steel mill specialists of the General Electric Company. Ask our nearest office for co-operation which will be gladly given.

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Schenectady, N. Y.
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